

TWR-17543 Vol. IV

Flight Set 360T004 (STS-30)  
Seals Final Report

March 1990

**Prepared for:**

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
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***Thiokol* CORPORATION**  
**SPACE OPERATIONS**

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## 1.0 INTRODUCTION

This report assesses the performance of 360T004, Forth Flight, Redesigned Solid Rocket Motors (RSRM) in respect to joint sealing issues as seen from post-test inspection of the seals and sealing surfaces. The factory joint disassembly inspections for this flight set were omitted. The decision was based on the rationale that there is sufficient information in the present data base, and this would give H-7 refurbishment operations faster turn around time for this set of hardware. The factory joint disassembly inspections will resume for 360H005, Fifth Flight, through 360L007, seventh flight, due to a new grease application being in effect during the assembly process. The left hand nozzle was forced into the snubbed position upon splash down. This required unique tooling to be manufactured to perform the disassembly of the internal nozzle joints. This was completed on February 5 and 6 1990 at the H-5 Clearfield Utah facility.

Figure 1 illustrates the RSRM consisting of capture feature field joints with the J-joint insulation configuration (see Figure 2). Figure 3 illustrates the nozzle-to-case joint design, which includes 100, 7/8-inch radial bolts in conjunction with a wiper O-ring and modified insulation design.

The ignition system seals and a cross section of the igniter are illustrated in Figures 4 and 5. Figures 6 through 10 show the configuration of all internal nozzle joints.

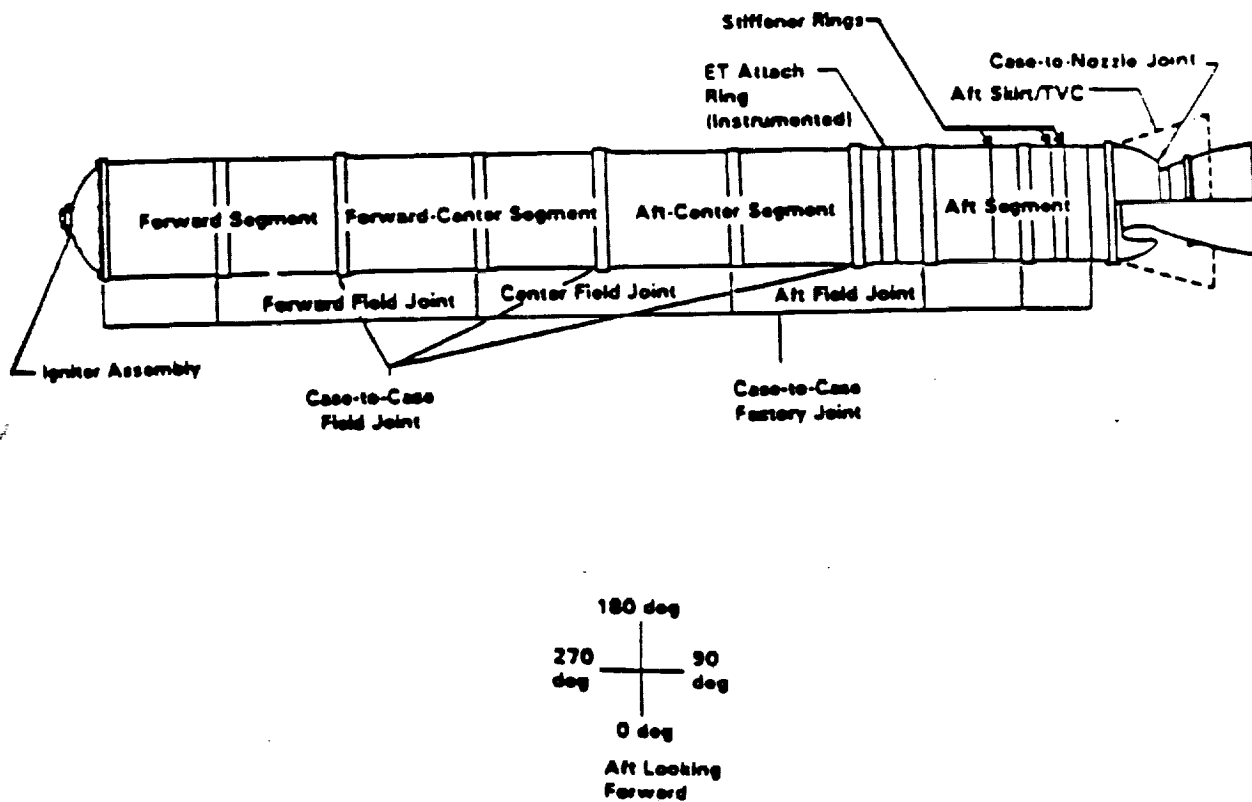


Figure 1  
RSRM Motor Configuration

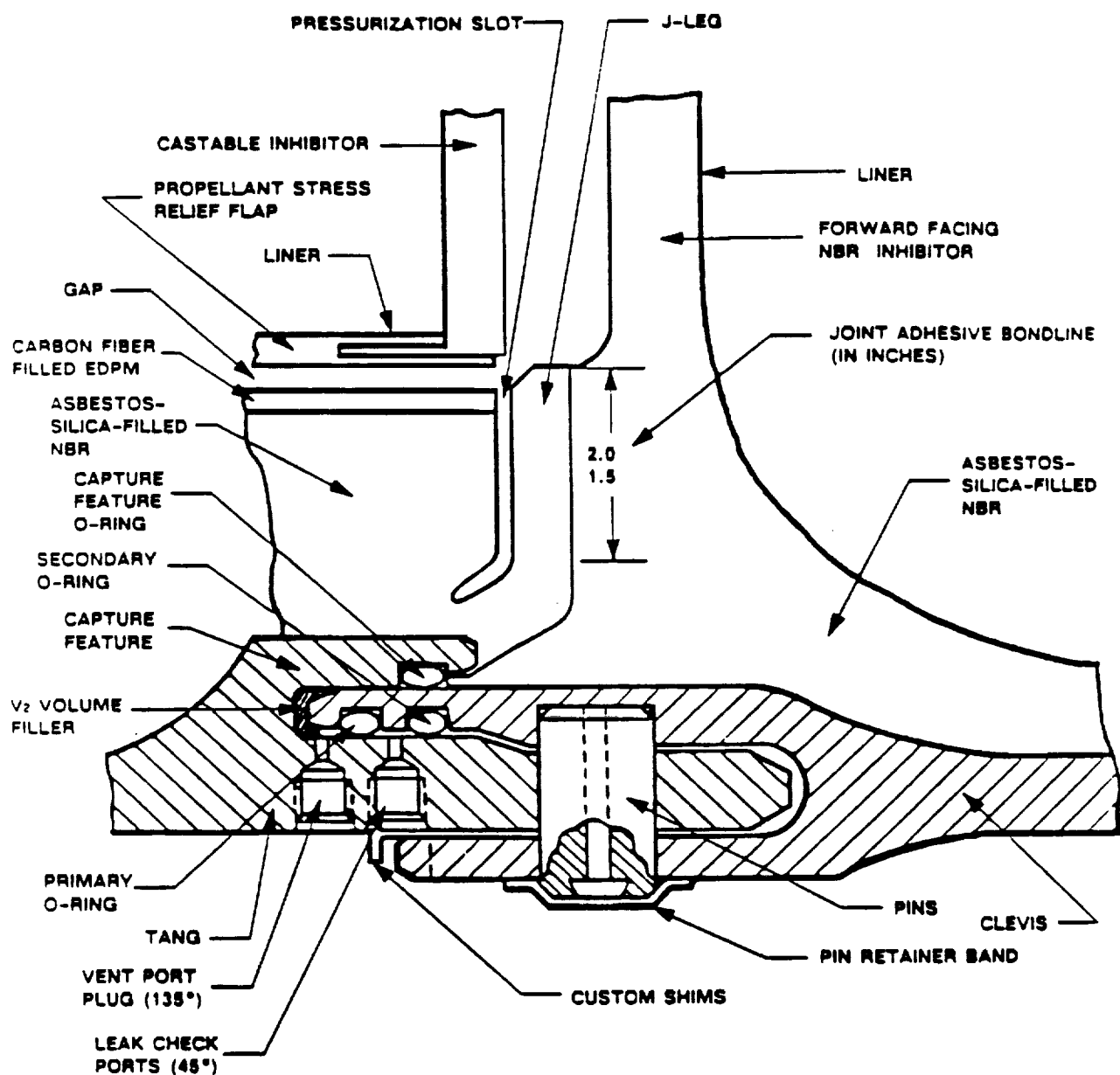


Figure 2  
RSRM Assembled Field Joint

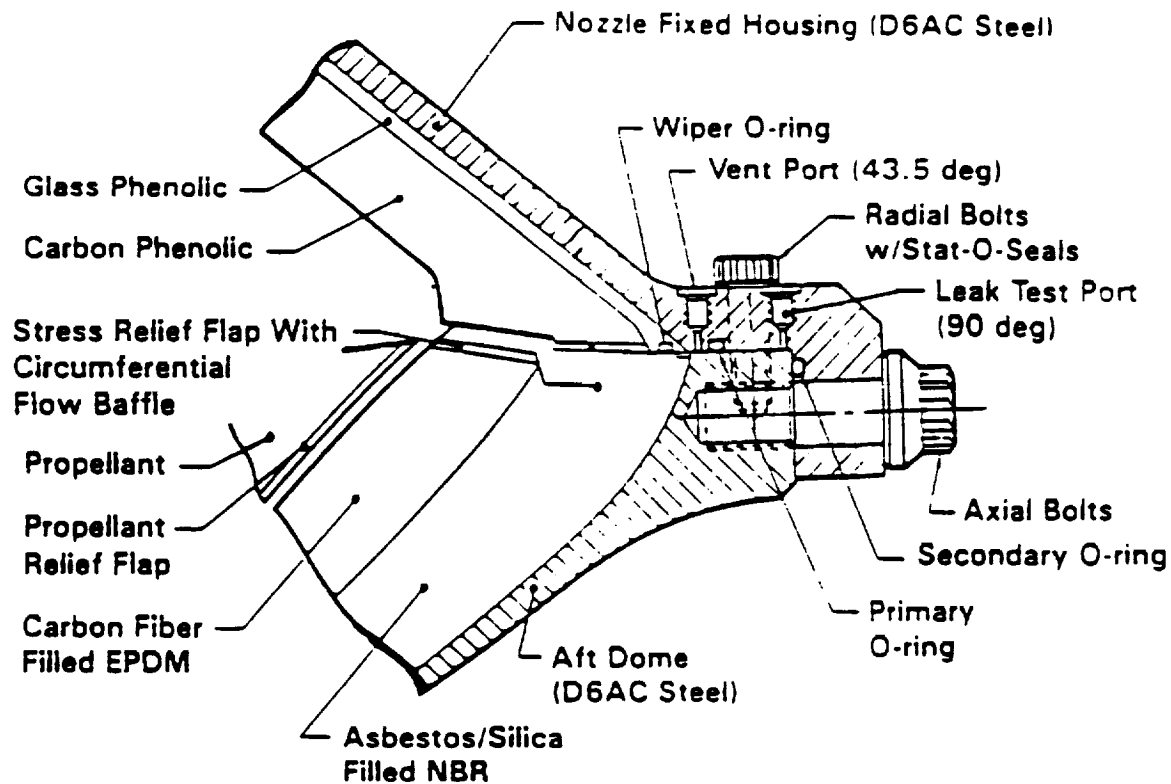


Figure 3  
Nozzle-to-Case Joint



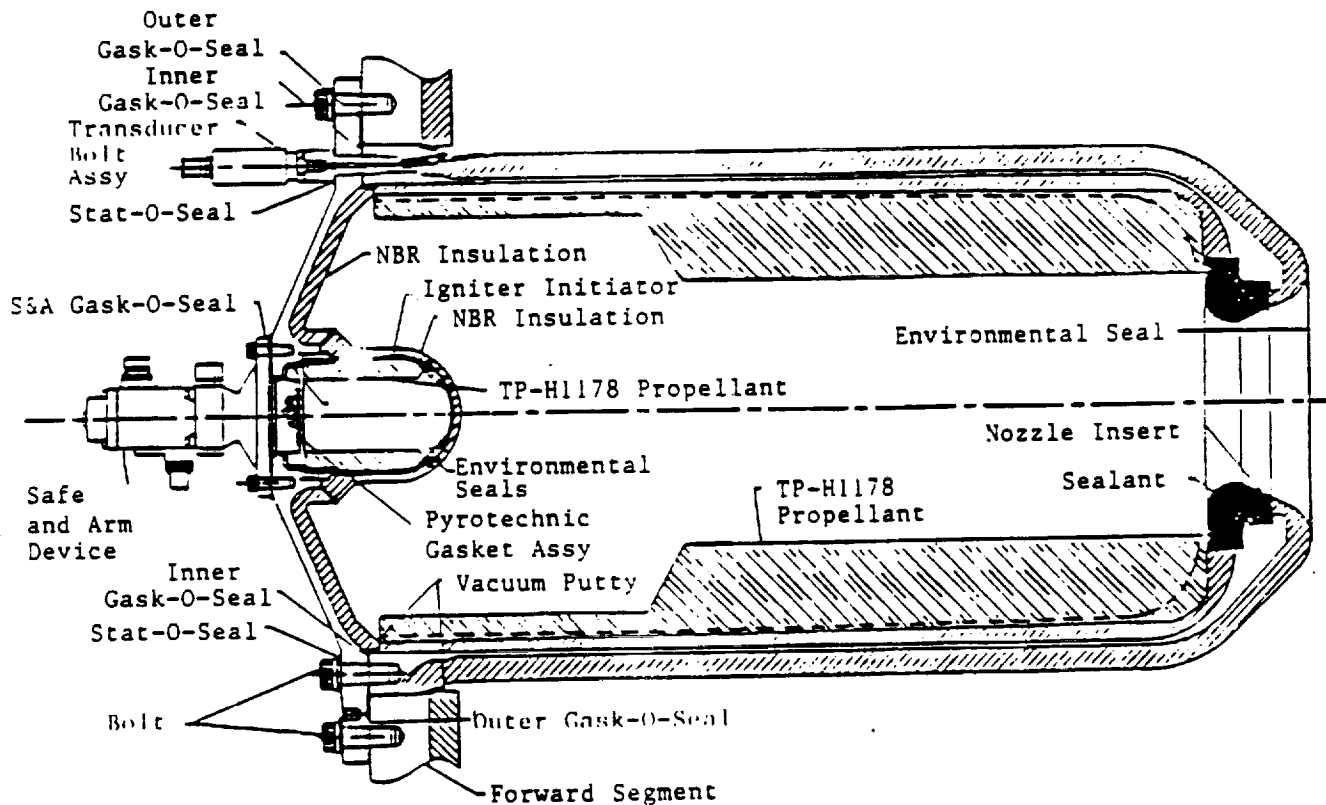


Figure 4  
Igniter Cross Section

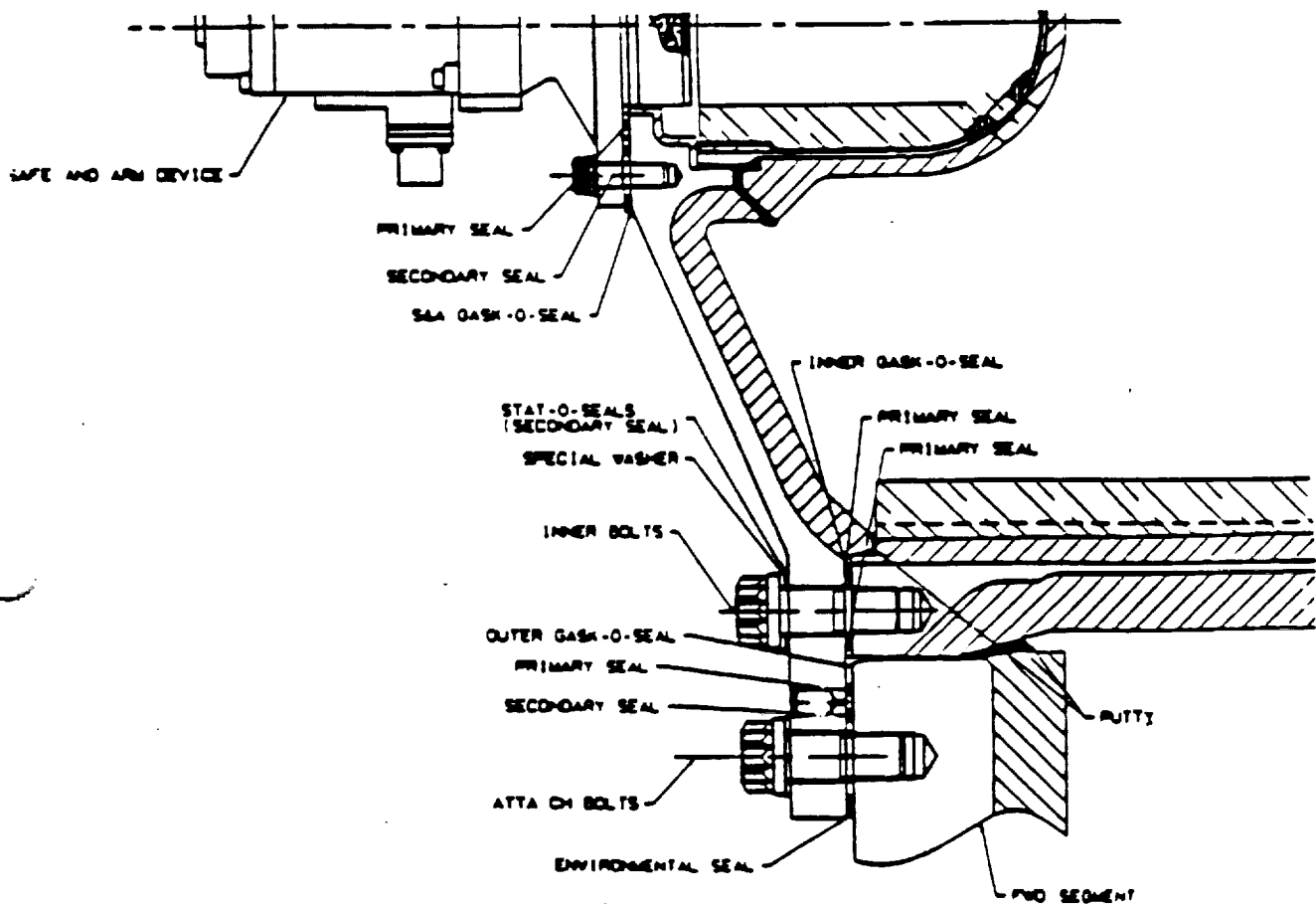


Figure 5  
Ignition System Seals

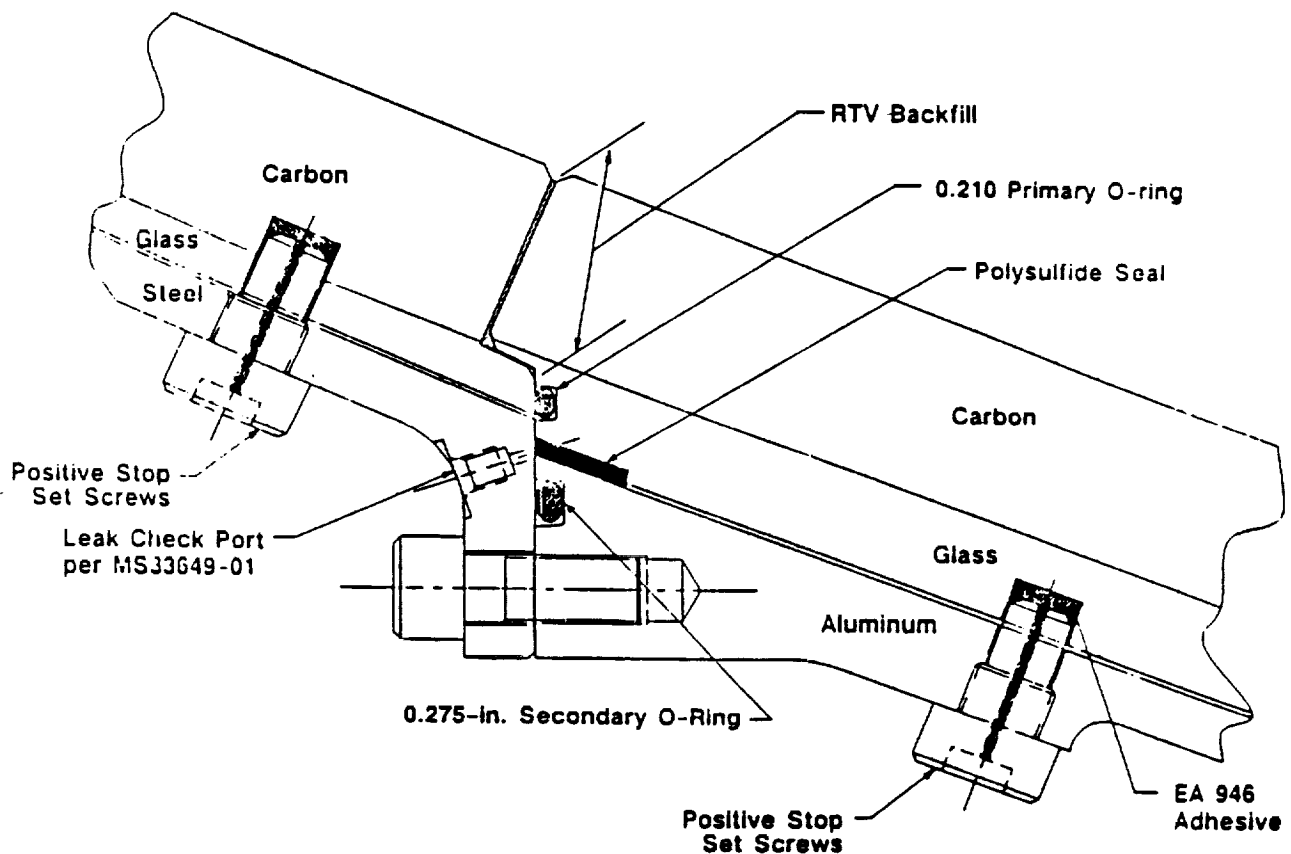
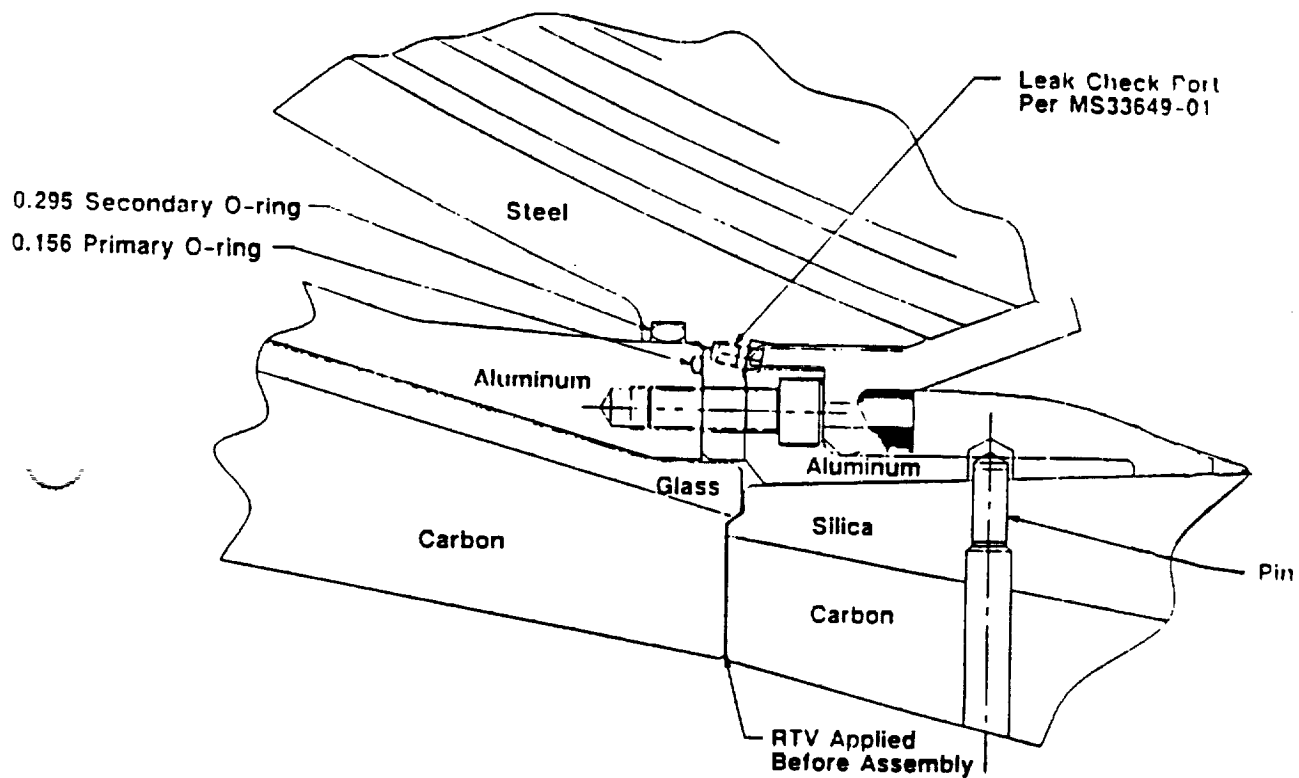
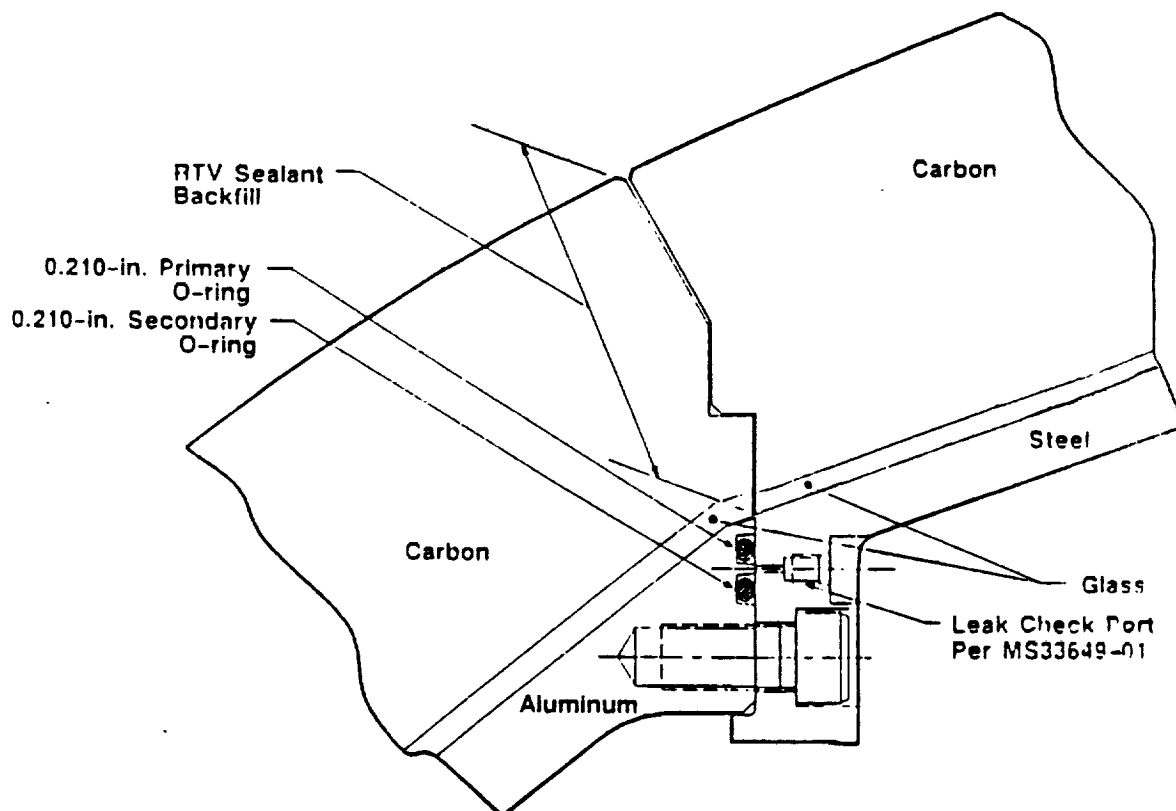


Figure 6  
Forward Exit Cone-to-Aft Exit Cone Joint



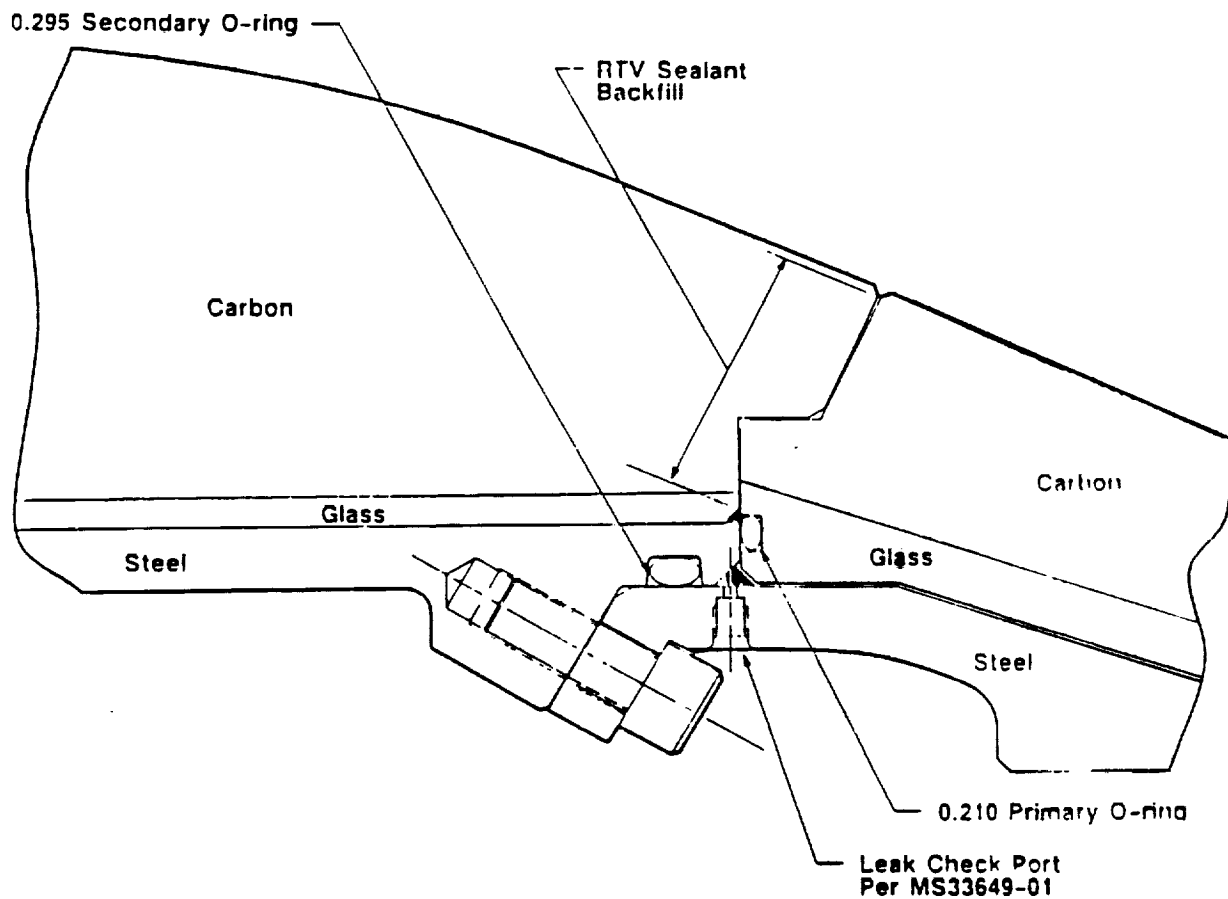
**Figure 7**  
**Nose Inlet Housing-to-Throat Support Housing Joint**



**Figure 8**  
**Nose Inlet Housing-to-Throat Support Housing Joint**

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**Figure 9**  
**Throat Support Housing-to-Forward Exit Cone Joint**

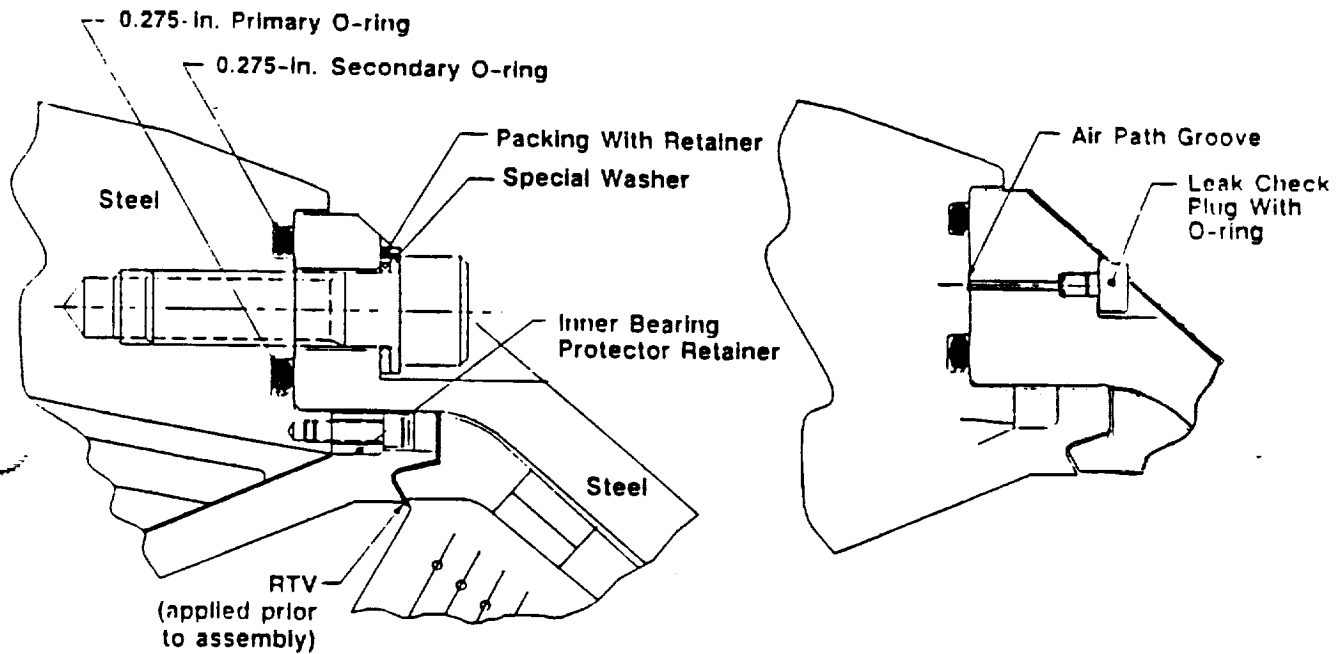


Figure 10  
Aft End Ring-to-Fixed Housing Joint

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## 2.0 SUMMARY

### 2.1 Post-Fire Inspection Summary

The post-flight inspection of both motors showed the seals component to be in excellent condition except for cut found in the secondary seal of the left hand outer igniter gasket, forward face (see Section 5.1.3). Also the secondary O-ring from the left motor custom vent port plug installed in the center field joint sustained assembly extrusion damage. Detailed inspection results, and inspections performed by the O-ring Inspection Team can be found in Section 5.0 of this report.

The Component Program Teams (CPT) have identified thirteen observations, made during disassembly inspections, as "potential anomalies." The thirteen potential anomalies were further classified as two remains observations, ten minor anomalies, and one major anomaly. These classifications are further discussed in Section 5.4.

There was no evidence of hot gas or soot past the J-Leg insulation on the six field joints or past the polysulfide on the two nozzle-to-case joints. The igniter joints showed no hot gas or soot past the primary seals. There was no soot to the aft exit cone primaries and there was no evidence of soot or hot gas past the primary seals on any of the internal nozzle joints. The right nozzle-to-case joint wiper O-ring sustained disassembly damage when the fixed housing was removed unevenly.



There was light surface corrosion on the outer clevis leg on all the field joints, no corrosion was found on any sealing surfaces. Intermittent aluminum corrosion ( $Al_2O_3$ ) was found between the primary and secondary seals on the right aft exit cone joint. Overall the grease application to all field and nozzle-to-case joints was nominal.

### 3.0 O-RING SQUEEZE AND LEAK CHECK RESULTS

Post fire inspection objectives are addressed in vol. 1 to this report, (see Reference 1). Calculations for the 360T004 O-ring squeeze are given in TWR-18760 (see Reference 2). The results of the leak check of the 360T004 boosters are addressed in detail in TWR-18797 (see Reference 3).

### 4.0 STRUCTURAL ASSESSMENT

This section normally details the structural assessment of the case field joints, factory joints, nozzle-to-case joint, and case metal components with comparisons to flight envelopes and previous flights. However there was no DFI installed on this flight set, therefore no structural assessment is addressed in this report.

## 5.0 POST-FIRE INSPECTION RESULTS

Joints and Seals Design Engineering performed a post-fire evaluation of the 360T004 forward, center, and aft field joints, aft exit cone field joints, nozzle-to-case joints, the igniter, and safe and arm joints at Hangar A-F, Kennedy Space Center (KSC), Florida. The internal nozzles were disassembled and inspected at the H-5 refurbishment facility in Clearfield, Utah. The objective of this section is to document the post-fire condition of the 360T004 sealing surfaces and seals as noted during disassembly, and to discuss all observations assessed by the Seal Component Team.

In an attempt to standardize and document the evaluation of flight motors, a standard evaluation plan has been written (see References 4 and 5). Appropriate procedures contained in this plan were used to evaluate the sealing system of all joints contained in the RSRM. The intent of this plan is to ensure that all pertinent evaluation points of 360T004 are examined and documented in a consistent and complete manner.

The left motor will be discussed first, then the right motor. The evaluation will start at the igniter and proceed down the motors to the aft exit cones. The following guidelines have been established to classify O-ring, gasket, Stat-O-Seal and corrosion damage found from post flight/test inspections. These guidelines were established so that each inspection data base will be consistent and not be confusing or misleading. Some of these definitions are used in this document.

O-RINGS , GASKETS AND STAT-O-SEALS

<u>Cut:</u>	Width, essentially zero (have to open up to find the damage), and depth greater than 0.005 inch.
<u>Scratch:</u>	Width less than 0.005 inch and depth less than 0.005 inch.
<u>Nick:</u>	Width less than 0.020 inch, but greater than 0.005 inch; and depth less than 0.010 inch, but greater than 0.005 inch.
<u>Gouge:</u>	Width greater than 0.020 inch and depth greater than 0.010 inch.
<u>Circumferential or Radial Flowline:</u>	Visible evidence of incomplete flow or knit of the material.
(i) Closed:	Tightly adhered, not separable, does not open when lightly probed.
(ii) Separable:	Visually appears closed. Separates when lightly probed.
(iii) Open:	Obvious separation or gap.
<u>Hard Inclusion:</u>	Foreign material enclosed in the seal material.
<u>Porosity/Soft Inclusion:</u>	An air pocket enclosed in the seal material.
<u>Extrusion Damage:</u>	Seal material pinched and/or cut due to an overfill condition.
<u>Heat Effect:</u>	Glossy and/or hardened seal surface due to hot gas impingement.
<u>Erosion:</u>	Seal material missing due to hot gas impingement or blow by.

## CORROSION

<u>Light Corrosion:</u>	can be wiped off by hand. Surface discoloration.
<u>Medium Corrosion:</u>	Can not be wiped off by hand without the use of a Scotch-Brite material, methyl chloroform, or grease soaked rag.
<u>Heavy Corrosion:</u>	Starting to penetrate into the metal surface such that pitting and/or metal material is significantly eroded.

### 5.1 Left Motor Disassembly Evaluation

There were no critical observations found on the left motor.

#### 5.1.1 External Walk Around

The external walk around inspection revealed no signs of hot gas leakage past any joint.

#### 5.1.2 Safe and Arm Joint

Heavy soot was observed to the primary seal on the gasket forward face the full circumference. There was no soot past the primary seal. There was no soot up to the primary seal on the gasket aft face. Medium intermittent corrosion was found inboard of the primary seals on both sides of the gasket. No damage was observed to the joint or gasket seals at the time of disassembly. Detailed inspection of the gasket by the O-ring inspection team also revealed no damage.

Detailed inspection of the S&A upon disassembly revealed the primary and secondary O-rings of the rotor shaft were in good condition, with no evidence of blow-by or heat effects found. The inspection of the primary O-ring region showed little evidence of soot up to the O-ring gland. The secondary O-rings were in good condition with no evidence of damage found.

The Teflon O-ring retainers used had heavy deformation at the assembly slit. The current leak check requires pressure of 3168,  $\pm 100$  psig which deforms the retainer. The severity of the deformation is dependent upon the number of pressurizations required to correctly test each unit. A test plan is being released which will evaluate a leak test pressure lower than 3000 psig to alleviate this problem.

Inspection of the barrier booster (B-B) rotor shaft housing bore revealed scratches that could be felt using a 5 and 10 mil piece of brass shim stock. The scratches were on the secondary sealing surface similar in footprint to three units previously found at ECC (the vendor). It was determined that these scratches were caused by the bore micrometer used to measure the bore diameters prior to assembly.

The inspection of the B-B leak check port plug (126 degrees) revealed a radial scratch across the sealing surface. The S&A-to-Adapter leak check port plug (306 degrees) had circumferential machining gouges on the sealing surface. This is most likely a machining defect caused during manufacturing.

The initiators were removed from the B-B and inspected. No evidence of blow-by was found past the threads. The primary sealing surface of each initiator was inspected for threads protruding into the sealing region. One initiator had unsatisfactory threads.

Inspection of the leak check paths between the primary and secondary O-rings of the initiator showed grease in all leak check holes. The grease could have masked the leak test of each initiator installed into the S&A devices. This is possible because of the low pressure used in the test and the close fit between the initiator and the leak check path. This same condition was found on other flight and test units. Testing to better determine the effectiveness of the leak test is being investigated.

#### 5.1.3 Outer Igniter Joint (Adapter-to-Forward Dome)

A blow path through the zinc chromate putty was present at 225 degrees. The starting jet was 1.5 inches wide and necked down to a through jet of 0.250 inch wide. Light soot was noted to travel the full joint circumference, whereas heavy soot was observed an arc of 60 degrees centered at the blowhole location. No soot was present on the gasket, inboard on the primary seals on either side.

A nick was found on the secondary gasket seal, forward face at 285 degrees. It started on the crown center and extended radially inward. Approximate dimensions are 0.10 inch long by 0.010 inch wide by 0.030 inch deep.

Corrosion was found on the inner edge of the gasket at 225 degrees due to the hot gas impingement at the blowhole location. Intermittent light corrosion was found on the forward dome boss inboard on the primary seal footprint at the same location. Medium corrosion was also found on the forward dome boss interior surface intermittently the full circumference.

#### 5.1.4 Inner Igniter Joint (Adapter-to-Chamber)

A terminated blow path through the zinc chromate putty was found at 35 degrees. No soot or damage was observed on the gasket seals. No corrosion was found on the gasket or joint metal surface. All stat-o-seals from the inner joint bolts were damaged during disassembly.

There was heavy soot on the end of special bolts, and light soot to the primary seals at 40, 100, 180, and 270 degrees. Medium corrosion was also found on the end of the special bolt at 40 degrees.

Inspection of the OPTs (operational pressure transducers) located at 40, 180, and 270 degrees showed soot deposits on the foremost threads, however no soot reach the primary seals. Inspection of the special bolt plugs located at 100 and 115 degrees revealed no anomalous conditions to the seals or plugs.

#### 5.1.5 Forward Field Joint

No hot gas or soot was past the J-leg. The grease coverage was per design. No corrosion was found on any sealing surface. Light intermittent pin hole and shim area corrosion was found on the inner surface of the outer clevis leg. The outside diameter of the outer clevis leg showed intermittent light surface corrosion from zero to 360 degrees on the one inch unpainted surface. The joint was heavily contaminated with debris from hydrolaze operations, which is used to remove the joint protection system.

No seal damage was observed at the time of disassembly, and the V2 filler was properly installed with no visible damage. Detailed inspection of the large diameter O-rings revealed no damage to primary or secondary. Three very light circumferential scratches were found on the capture feature O-ring. The worst case located between 65.4 and 77.2 degrees and measuring 14.5 inches in length with a width of approximately 0.001 inch and an indeterminable depth.

#### 5.1.6 Center Field Joint

There was no sign of hot gas or soot past the J-leg. The grease coverage was per design and no corrosion was found on any sealing surface. No corrosion was found on any of the joint interior surface. The outside diameter of the outer clevis leg showed very light intermittent corrosion from zero to 360 degrees on the one inch unpainted surface.



The joint was slightly contaminated with hydrolaze debris. No seal damage was observed on the primary or secondary O-rings during disassembly. The V2 filler was properly installed with no visible damage was found. Detailed inspection of the large diameter O-rings revealed no damages.

#### 5.1.7 Aft Field Joint

There was no sign of hot gas or soot past the J-joint. The grease coverage was per design and no corrosion was found on any sealing surfaces. The outside diameter of the outer clevis leg showed very light intermittent corrosion from zero to 360 degrees on the one inch unpainted surface. The joint was slightly contaminated with debris and water from hydrolaze operations. No seal damage was observed at the time of disassembly and the V2 filler was properly installed with no visible damage. Detailed evaluation of the large diameter O-rings by the O-ring inspection team revealed no damages. White thin lines of Teflon tape adhesive was found on the aft side of the capture feature O-ring at 160 and 320 degrees. This condition is acceptable per the PEEL document (Postflight Engineering Evaluation Limits, TWR-18680, volume 4).

#### 5.1.8 Nozzle-to-Case Joint

There was no evidence of hot gas or soot past the polysulfide. The grease application was per specification. There was no corrosion found on either the fixed housing or the aft dome.

No polysulfide extruded past the wiper O-ring. No radial bolt hole disassembly plugs were damaged during the disassembly process.

There were no signs of O-ring damage at the time of disassembly on the primary, secondary, or wiper O-rings. Detailed inspection of the O-rings found no damage on the primary O-ring. The secondary O-ring had 2 very light circumferential scratches located between 36 and 40.3 degrees. The worst case measuring 2.75 inch in length by 0.001 inch wide with an indeterminable depth. Also found on the secondary O-ring were 2 light diagonal scratches located at 72 and 330 degrees. Each measured 0.250 inch in length and 0.001 inch in width and depth. The wiper O-ring had 2 areas of light diagonal scratches located at 70.2 and 342.8 degrees. The worst case measured 0.170 inch in length and 0.001 inch in width and depth. Also found on the wiper O-ring were 7 very light circumferential scratches located intermittently around the circumference. The worst case was located from 275.8 to 289.9 degrees and measured 12.75 inch in length and 0.001 inch width with an indeterminable depth. Inspection of the Stat-O-Seals found 4 separable flowlines, 24 closed flowlines, 8 with excessive grinding, and 23 with corroded retainers.

#### 5.1.9 Aft Exit Cone Joint (Joint 1)

No pressure paths were found through the RTV, so no pressure or soot reached the primary O-ring. Light oxidation/corrosion was found between O-ring grooves on the aft exit cone forward face from 30 to 128 degrees.

The in groove inspection of the O-rings showed no anomalous conditions. Detailed inspection by the O-ring inspection team revealed a radial nick on the primary O-ring located at 130 degrees measuring 0.100 inch in length by 0.010 inch in width by 0.005 inch depth. The secondary O-ring sustained a very light circumferential scratch located between 136.7 and 151.3 degrees, measuring 11.5 inches long by 0.001 inch wide with an indeterminable depth. The cause of the nick is suspected to been caused by the O-ring clips which are used to hold the O-rings in place during disassembly.

#### 5.1.10 Forward End Ring-To-Nose Inlet Housing (Joint 2)

Evaluation of the joint did not revealed any obvious pressure paths through the RTV/adhesive of the joint interface. Typical scalloped shaped sooting was observed around the full circumference of the joint about half way between the edge of the aluminum housing and the primary O-ring groove situated between bolt holes. No evidence of blowby was observed up to or past the primary O-ring. No damage to the primary or secondary O-rings was found during the in groove evaluation or by the O-ring inspection team. The sealing surfaces suffered no assembly or disassembly damage. The joint had excessive grease in the primary and secondary grooves and was thicker than prescribed in STW7-2999.

#### 5.1.11 Nose Inlet Housing-To-Throat Support Housing (Joint 3)

No soot or evidence of blowby was present past the primary O-ring. No damage was found during the in groove evaluation of the primary or secondary O-rings or by the O-ring inspection team. The sealing surfaces revealed no signs of damage. Typical light corrosion was found intermittently on the nose inlet forward of the primary O-ring. Light corrosion was observed up to the primary O-ring at 175 though 285 degrees.

#### 5.1.12 Forward Exit Cone-To-Throat Support Housing (Joint 4)

Evaluation of the joint revealed no pressure paths through the RTV backfill. No damage was observed on the primary or secondary O-rings at the time of disassembly or by the O-ring inspection team. The sealing surfaces suffered no assembly/disassembly damage.

#### 5.1.13 Fixed Housing-To-Aft End Ring (Joint 5)

No pressure paths were observed through the RTV. RTV mixed with corrosion was observed up to the land forward of the primary O-ring the full circumference. No damage was observed on the primary or secondary O-rings at the time of disassembly or by the O-ring inspection team. The sealing surface revealed no signs of damage. Light corrosion of the metal outward of the secondary O-ring was observed the entire circumference between 195 to 200 degrees.

## 5.2 Right Motor Disassembly Evaluation

There were no critical observations found on the right motor.

### 5.2.1 External Walk Around

The external walk around inspection revealed no signs of hot gas leakage past any joints.

### 5.2.2 Safe and Arm Joint (Adapter-to-Barrier Booster)

There was soot up to the primary seal on both sides of the S&A gasket. No soot was observed past the primary seals. Intermittent medium corrosion was found on the surface of the metal retainer inboard of the primary seal on both sides of the gasket (soot locations), and gasket inner edge. No other damage (besides the noted corrosion) was found to the joint or gasket seals at the time of disassembly. Detailed inspection of the gasket by the O-ring inspection team revealed no anomalous conditions.

Detailed inspection of the S&A upon disassembly revealed the primary and secondary O-rings of the rotor shaft were in good condition, with no evidence of blow-by or heat effects found. The inspection of the primary O-ring region showed little evidence of soot up to the O-ring gland. The secondary O-rings were in good condition with no evidence of damage found.

The Teflon O-ring retainers used had a small amount of deformation. The current leak check requires a leak check pressure of 3168,  $\pm 100$  psig which deforms the retainer. The severity of the deformation is dependent upon the number of pressurizations required to correctly test each unit. A test plan is being released which will evaluate a leak test pressure lower than 3000 psig to alleviate this problem.

Inspection of the barrier booster (B-B) rotor shaft housing bore revealed scratches which could be felt using a 5 and 10 mil piece of brass shim stock. It was determined that these scratches were caused by the bore micrometer used at ECC (the vendor) to measure the bore diameters prior to assembly. Scratches were found on both the primary and secondary sealing surfaces. The footprint of these scratches was different from that of the left S&A. The scratches could have been caused by any device capable of providing a thin line scratch.

The B-B leak check port plug (126 degrees) had a radial scratch across the sealing surface. The initiators were removed from the B-B and inspected. No evidence of blow-by was found past the threads. The primary sealing surface of each initiator was inspected for threads protruding into the sealing region. One initiator had unsatisfactory threads.

Inspection of the leak test paths between the primary and secondary O-rings of the initiator showed grease in the leak check holes. The grease may have masked the leak test of each initiator installed into the S&A device.

This is possible because of the low pressure used in the test and the close fit between the initiator and the leak check path. This same condition was found on other flight and test units. Testing to better determine the effectiveness of the leak test is being investigated.

#### 5.2.3 Outer Igniter Joint (Adapter-to-Forward Dome)

There was no evidence of hot gas leakage past the primary seal. A putty blow hole was observed at 265 degrees. All the soot traveled towards 175 degrees. Soot was found on the aft face of the gasket, inboard of the primary seal, and the igniter chamber from 175 to 270 degrees. No soot was found on the gasket forward face or igniter adapter. Heavy soot was found on the gasket aft face, inboard of the primary seal, from 225 to 265 degrees. Intermittent corrosion was found on the inside edge of the forward dome boss inboard of the primary sealing surface. No gasket seal damage was observed at the time of disassembly.

#### 5.2.4 Inner Igniter Joint (Adapter-to-Chamber)

No blow holes were found in the putty, therefore no soot reached the inner primary seal. All stat-o-seals from the inner joint bolts were damaged during disassembly. No gasket seal damage was observed at the time of disassembly.

There was heavy soot on the end of special bolts, and light soot to the primary seals at 40, 100, 180, and 270 degrees. Medium corrosion was also found on the end of the special bolt at 100 degrees.

Inspection of the OPTs (operational pressure transducers) located at 40, 180, and 270 degrees showed soot deposits on the foremost threads, however no soot reach the primary seals. Inspection of the special bolt plugs located at 100 and 115 degrees revealed no anomalous conditions to the seals or plugs.

#### 5.2.5 Forward Field Joint

There was no sign of hot gas or soot past the J-leg. The grease coverage was per design and no corrosion was found on any sealing surface. Light intermittent corrosion spots were observed on the outside diameter of the tang, forward of the pin holes. The outside diameter of the outer clevis leg showed intermittent light surface corrosion from zero to 360 degrees on the one inch unpainted surface. The joint was heavily contaminated with debris from hydrolaze operations, which is used to remove the joint protection system.

No seal damage was observed at the time of disassembly, and the V2 filler was properly installed with no visible damage. Detailed inspection of the large diameter O-rings revealed no damages.



#### 5.2.6, Center Field Joint

There was no sign of hot gas or soot past the J-leg. The grease coverage was per design and no corrosion was found on any sealing surface. No corrosion was found on any of the joint interior surface. The outside diameter of the outer clevis leg showed very light intermittent corrosion from zero to 360 degrees on the one inch unpainted surface. The joint was heavily contaminated with debris from hydrolaze operations. No seal damage was observed on the primary or secondary O-rings at the time of disassembly. The V2 filler was properly installed and no visible damage was found. Detailed inspection of the large diameter O-rings revealed no damages.

#### 5.2.7 Aft Field Joint

There was no sign of hot gas or soot past the J-leg. The grease coverage was per design and no corrosion was found on any sealing surface. Light intermittent pin hole and shim area corrosion was found on the inner surface of the outer clevis leg. The outside diameter of the outer clevis leg showed intermittent light surface corrosion from zero to 360 degrees on the one inch unpainted surface. Medium corrosion was also found on the tang bottom tip from 146-150 degrees. The joint was heavily contaminated with debris from hydrolaze operations.

No seal damage was observed at the time of disassembly, and the V2 filler was properly installed with no visible damage. Detailed inspection of the large diameter O-rings revealed no damages.

#### 5.2.8 Nozzle-to-Case Joint

There was no evidence of hot gas or soot past the polysulfide. The grease application was per specification. There was no corrosion found on either the fixed housing or the aft dome. No polysulfide extruded past the wiper O-ring. The radial bolt hole disassembly plugs at 63 and 156.6 degrees suffered damage. The wiper O-ring was cut in half at 216.1 degrees when it became caught on the GSE jack screw, and also gouged almost completely through at 335.7 degrees. Both of the damaged locations of the wiper O-ring are attributable to an uneven disassembly.

There were no signs of O-ring damage at the time of disassembly on the primary or secondary O-rings. Detailed inspection of the large diameter O-rings by the O-ring inspection team revealed no additional observations. Inspection of the Stat-O-Seals found 2 nicked seals, the worst case being 0.060 inch in length, 0.010 inch width, and 0.005 inch depth. In addition 12 closed flowlines, 1 separable flowline, 3 with excessive grinding, and 19 retainers with corrosion on the outer edge was also observed.

#### 5.2.9 Aft Exit Cone Joint (Joint 1)

No pressure paths were found through the RTV, so no pressure or soot reached the primary O-ring. Intermittent oxidation/corrosion was found at the polysulfide groove to aluminum housing interface on the aft exit cone.

No damage to the primary or secondary O-rings were observed at the time of disassembly. Inspection of the large diameter O-rings conducted by the inspection team revealed no damages.

#### 5.2.10 Forward End Ring-To-Nose Inlet Housing (Joint 2)

Inspection of the joint did not revealed any obvious pressure paths through the RTV/adhesive of the joint interface. Soot reached the primary O-ring at 14 to 30, 90 to 93, and intermittently between 51 to 69 degrees. Heavy sooting was found in the joint interface from zero to 30 and 84 to 120 degrees. Scalloped shaped sooting of the grease was found about half way between the edge of the aluminum housing and the primary O-ring groove situated between bolt holes around the entire circumference. No soot or evidence of blowby was present past the primary O-ring. No apparent damage to the primary or secondary O-rings was found on in the groove inspection, and the sealing surfaces suffered no assembly or disassembly damage. Detailed inspection of the large diameter O-rings by the O-ring inspection team revealed no damages.

#### **5.2.11 Nose Inlet Housing-To-Throat Support Housing (Joint 3)**

Detailed inspection revealed no anomalies to the joint. No apparent damage was found during preliminary inspection of the primary or secondary O-rings. Inspection of the sealing surfaces revealed no signs of damage. Detailed inspection of the large diameter O-rings by the O-ring inspection team revealed 2 very light circumferential scratches on the primary located between 126.9 to 141.1 degrees (worst case), and 156.2 to 162.5 degrees. The worst case measured 8.5 inch in length, by 0.001 inch width, by an indeterminable depth. No damage was observed on the secondary O-ring.

#### **5.2.12 Forward Exit Cone-To-Throat Support Housing (Joint 4)**

Inspection of the joint revealed no pressure paths through the RTV backfill. No apparent damage to the primary or secondary O-rings was found during preliminary inspection, and the sealing surfaces suffered no assembly/disassembly damage. Detailed inspection of the large diameter O-rings by the O-ring inspection team revealed no damage found.

#### **5.2.13 Fixed Housing-To-Aft End Ring (Joint 5)**

Detailed inspection revealed no anomalies to the joint. No damage was found during preliminary inspection of the primary or secondary O-rings. Inspection of the sealing surface revealed no signs of damage.

Detailed inspection of the large diameter O-rings by the O-ring inspection team revealed no damages. Inspection of all the Stat-O-Seals showed typical disassembly damage.

### 5.3 Leak Check and Vent Port Plug Post Flight Evaluations

The evaluation of the port plugs after flight use consisted of adding to the port plug torque database, visual inspection of the port plug for damage, and visual inspection of the port plug O-rings for anomalies.

The port plugs had breakaway torques recorded. This exercise was done to add to the port plug torque database so evaluation of installation torque levels and locking devices can be made on each port plug.

A summary of the post flight inspection evaluations of the port plugs and port plug O-rings is contained in table 1. Port plugs in the field joints and nozzle to case joints were removed during disassembly operations at KSC. Port plugs in the internal nozzle joints and igniter were removed at Clearfield. An initial inspection was done at that time. Factory joints were not inspected at Clearfield, but a final inspection was performed. Closure plugs were removed from the custom vent port plugs by the O-ring Inspection Team. All port plugs and O-rings were then inspected by the O-ring Inspection Team as a final inspection.

During the initial inspection at KSC several observations were reported. The most recurrent observation was extrusion damage to the O.D. and I.D. of the primary O-ring on the adjustable vent port plug. The extrusion damage was caused during installation of the port plug into the port. This damage is an acceptable condition due to the design of the primary seal. The primary O-ring is used as a packing seal. When the adjustable vent port plug is fully installed in the vent port, the primary O-ring extrudes out of the gland area and is damaged. The damage is inherent to the design.

Initial inspection of the port plugs removed at Clearfield continued to find several reoccurring problems. The lack of grease on some port plugs, O-rings and/or ports was noted. Port plug head gouges/scratches were reported on one factory joint leak check port plug. The damage is caused by pneumatic chisels used to remove the weather seal. This does not affect the use or removal of the port plug but the breakaway torque readings taken for evaluation are invalidated.

Final inspection of port plugs and O-rings by the O-ring Inspection Team documented I.D. cut observations on the shoulder O-ring from fourteen port plugs. The observation consists of a cut that extends circumferentially around the I.D. of the O-ring. The length and depth varies. A sharp last thread on the port plug causes the cut. The cut occurs as the port plug is removed from the port and the O-ring is rubbed along the thread. O-ring installation aids were used to install the discrepant O-rings on the port plugs to prevent this type of damage during installation.

**Table 1**  
**360L004 LEAK CHECK AND VENT PORT PLUG POST FLIGHT INSPECTION RESULTS**

JOINT LOCATION	PART INSPECTED	LEFT HAND (4A)		RIGHT HAND (4B)	
		INITIAL INSPECTION	FINAL INSPECTION	INITIAL INSPECTION	FINAL INSPECTION
Forward Field	Adj. Vent Port Plug	No Damage	No Damage	No Damage	No Damage
	Primary O-ring	Extrusion Damage	O.D. Extr. Damage	Extrusion Damage	O.D. & I.D Extrusion
	Secondary O-ring	No Damage	No Damage	No Damage	No Damage
	Closure Plug O-ring	No Damage	No Damage	No Damage	No Damage
	Leak Check Plug O-ring	No Damage	No Damage	No Damage	No Damage
		No Damage	No Damage	No Damage	No Damage
Center Field	Adj. Vent Port Plug	No Damage	No Damage	No Damage	No Damage
	Primary O-ring	Extrusion Damage	O.D. & I.D Extr. Damage	Extrusion Damage	O.D. Extrusion Damage
	Secondary O-ring	Assem. Extr Damage	O.D. Circ. Extr. Damage (0.700" I.D. Circ. Cut)	No Damage	No Damage
	Closure Plug	No Damage	No Damage	No Damage	No Damage
	O-ring	No Damage	No Damage	No Damage	No Damage
	Leak Check Plug	No Damage	No Damage	No Damage	Fiber Under O-ring in Circ. Dir.(1.0")

**Table 1 (Continued)**  
**360L004 LEAK CHECK AND VENT PORT PLUG POST FLIGHT INSPECTION RESULTS**

JOINT LOCATION	PART INSPECTED	LEFT HAND (4A)		RIGHT HAND (4B)	
		INITIAL INSPECTION	FINAL INSPECTION	INITIAL INSPECTION	FINAL INSPECTION
Aft Field	O-ring	No Damage	I.D. Circ. Cut (0.54" Length)	No Damage	I.D. Circ. Cut (0.30" Length)
	Adj. Vent Port Plug	Light Hex Marring	No Damage	Medium Rust on Plug Head	No Damage
	Primary O-ring	Extrusion Damage	O.D. & I.D. Extr. Damage	Extrusion Damage	O.D. & I.D. Extrusion
	Secondary O-ring	No Damage	No Damage	No Damage	No Damage
	Closure Plug	No Damage	No Damage	No Damage	No Damage
	O-ring	No Damage	No Damage	No Damage	No Damage
	Leak Check Plug	No Damage	No Damage	No Damage	No Damage
Nozzle to Case	O-ring	No Damage	I.D. Circ. Cut (.90" Length)	No Damage	I.D. Circ. Cut (.22" Length)
	Adj. Vent Port Plug	No Damage	No Damage	No Damage	No Damage
	Primary O-ring	Extrusion Damage	I.D. Extr. Damage	No Damage	O.D. & I.D. Extrusion
	Secondary O-ring	No Damage	Closed Flow Lines	No Damage	No Damage
	Closure Plug	No Damage	No Damage	No Damage	No Damage
	O-ring	No Damage	No Damage	No Damage	No Damage



**Table 1 (Continued)**  
**360L004 LEAK CHECK AND VENT PORT PLUG POST FLIGHT INSPECTION RESULTS**

JOINT LOCATION	PART INSPECTED	LEFT HAND (4A)		RIGHT HAND (4B)	
		INITIAL INSPECTION	FINAL INSPECTION	INITIAL INSPECTION	FINAL INSPECTION
Int. Noz Joints	Leak Check Plug	No Damage	No Damage	No Damage	No Damage
	O-ring	Light extr. Mark on O.D	No Damage	No Damage	No Damage
No.1	Leak Check Plug	Not Insp.	Not Received	Not Insp.	No Damage
No.2	O-ring	Not Insp.	Not Received	Not Insp.	No Damage
	Leak Check Plug	Not Insp.	Not Received	No Damage	No Damage
No.4	O-ring	Not Insp.	Not Received	No Damage	I.D. Circ. Cut (0.12" Length)
	Leak Check Plug	Not Insp.	Not Received	No Damage	No Damage
No.5	O-ring	Not Insp.	Not Received	No Damage	No Damage
	Leak Check Plug	Not Insp.	Not Received	No Damage	No Damage
Factory Joints	O-ring	Not Insp.	Not Received	No Damage	I.D. Circ. Cut (0.32" Length)
	Leak Check Plug	Not Insp.	No Damage	Not Insp.	No Grease on Threads
Forward Dome	O-ring	Not Insp.	No Damage	Not Insp.	I.D. Circ. Cut (0.04"
	Leak Check Plug	Not Insp.	No Damage	Not Insp.	

**Table 1 (Continued)**  
**360L004 LEAK CHECK AND VENT PORT PLUG POST FLIGHT INSPECTION RESULTS**

JOINT LOCATION	PART INSPECTED	LEFT HAND (4A)		RIGHT HAND (4B)	
		INITIAL INSPECTION	FINAL INSPECTION	INITIAL INSPECTION	FINAL INSPECTION
Forward Segment	Leak Check Plug	Not Insp.	No grease on Threads	Not Insp.	No Grease on Threads
	O-ring	Not Insp.	No Damage	Not Insp.	No Damage
Forward Center Segment	Leak Check Plug	Not Insp.	No Damage	Not Insp.	Rolled Thread
	O-ring	Not Insp.	No Damage	Not Insp.	No Damage
Aft Center Segment	Leak Check Plug	Not Insp.	No Damage	Not Insp.	No Damage
	O-ring	Not Insp.	No Damage	Not Insp.	No Damage
Attach to Stiffener	Leak Check Plug	Not Insp.	No Grease	Not Insp.	No Grease Rld Thread Chisel Goug
	O-ring	Not Insp.	No Grease I.D. Circ. Cut (0.90" Length)	Not Insp.	I.D. Circ. Cut (0.40" Length)
Stiff/ Stiff	Leak Check Plug	Not Insp.	No Damage	Not Insp.	No Grease
	O-ring	Not Insp.	I.D. Circ. Cut (0.70" Length)	Not Insp.	I.D. Circ. Cut (0.55" Length)
Aft Dome	Leak Check Plug	Not Insp.	Rolled Threa No Grease	Not Insp.	No Grease Chisel Gouge
	O-ring	Not Insp.	No Grease	Not Insp.	I.D. Circ. Cut (0.15" Length)

**Table 1 (Continued)**  
**360L004 LEAK CHECK AND VENT PORT PLUG POST FLIGHT INSPECTION RESULTS**

JOINT LOCATION	PART INSPECTED	LEFT HAND (4A)		RIGHT HAND (4B)	
		INITIAL INSPECTION	FINAL INSPECTION	INITIAL INSPECTION	FINAL INSPECTION
Igniter					
IPT	Transducer Primary O-ring	No Damage	Ding on First Thread	No Damage	2 Small Dings in Threads
	Secondary O-ring	No Damage	I.D. Circ. Cut (0.07" Length)	No Damage	No Damage
Outer Jnt	Leak Check Plug	No Damage	2 Radial Scratches on Underside of Plug Head	No Damage	Rolled Threads
	O-ring	No Damage	No Damage	No Damage	No Damage
Inner Jnt	Leak Check Plug	No Damage	No Damage	No Damage	Rolled Threads
	O-ring	No Damage	No Damage	No Damage	No Damage
Trans. (40 Deg.)	Primary	No Damage	3 Puncture Marks From Removal Tool	No Damage	No Damage
	Secondary	No Damage	Sm. Puncture	No Damage	Sm. Puncture
Trans. (100 Deg.)	Primary	No Damage	No Damage	No Damage	No Damage
	Secondary	No Damage	No Damage	No Damage	Sm. Puncture
Trans. (180 Deg.)	Primary	No Damage	No Damage	No Damage	No Damage
	Secondary	No Damage	Sm. Puncture	No Damage	Sm. Puncture

**Table 1 (Continued)**  
**360L004 LEAK CHECK AND VENT PORT PLUG POST FLIGHT INSPECTION RESULTS**

JOINT LOCATION	PART INSPECTED	LEFT HAND (4A)		RIGHT HAND (4B)	
		INITIAL INSPECTION	FINAL INSPECTION	INITIAL INSPECTION	FINAL INSPECTION
Trans. (270 Deg.)	Primary	No Damage	No Damage	No Damage	No Damage
	Secondary	No Damage	Sm. Puncture	No Damage	Sm. Puncture
Spec. Blt (40 Deg.)	Primary	No Damage	No Damage	Rust on End of Bolt	No Damage
	Stat-0-Seal	No Damage	No Damage	No Damage	No Damage
Spec. Blt 100 Deg.)	Primary	No Damage	No Damage	No Damage	No Damage
	Stat-0-Seal	No Damage	No Damage	No Damage	No Damage
Spec. Blt (180 Deg.)	Primary	No Damage	No Damage	No Damage	No Damage
	Stat-0-Seal	No Damage	No Damage	No Damage	No Damage
Spec. Blt (270 Deg.)	Primary	No Damage	No Damage	No Damage	No Damage
	Stat-0-Seal	No Damage	No Damage	No Damage	No Damage

#### **5.4 Post-Flight Team Assessments**

The Component Program Teams (CPT) have reviewed all of the observations presented in this document and have determined that the following observations were "potential anomalies", classified as critical, major, minor or remains observation, as defined under Table 2 criteria.

Each "potential anomaly" is tracked by a Post-Fire Anomaly Record (PFAR). Corrective actions and results of the corrective action are recorded on the PFAR. Once all the corrective actions on the PFAR are completed, the PFAR is closed.

##### **5.4.1 Remains Observation**

Two "potential anomalies" were classified as remains observation. These observations are:

- 1,2. Rolled threads on the last partial thread of 1U51475 and 1U100269 leak test plugs found on both RSRMs.

##### **5.4.2 Minor Anomalies**

Nine "potential anomalies" were classified as minor anomalies. These minor anomalies are:

- 1,2. Axial scratches with a maximum depth of 0.3 to 0.4 mils including raised metal found on the bore sealing surface of the barrier booster rotor shaft of both S&A devices.

- 3,4. Galled seal area on the S&A leak test port plug on both S&A devices.
- 5,6. Scratched seal area on the B-B leak test port plug on both S&A devices.
- 7,8. No grease on port, plug, and O-ring found on both RSRMs factory joints.
9. The secondary O-ring on the custom vent port plug in the left center field joint sustained assembly O.D. extrusion damage.
10. A small piece of flashing was found molded into the I.D. of the M83248/1 B-B leak test port plug O-ring, left motor.

#### 5.4.3 Major Anomalies

One "potential anomaly" was classified as major anomaly. The major anomaly is:

1. The secondary seal of the left outer igniter gasket was cut at 285 degrees, gasket forward face. The cut existed on approximately 50 percent of the crown and extended radially inward. Approximate dimensions are 0.10 inch long by 0.010 inch wide by 0.030 inch deep.

#### 5.4.4 Critical Anomalies

There were no critical anomalies.

### 5.5 RPRB Position

Each PFAR is taken to the RPRB and presented as recommended by the Component Program Team. The RPRB is asked for acceptance of the PFAR as presented. The RPRB has accepted all the recommendations as presented to the board (see Appendix A).

**Table 2**  
**Criteria for Classifying "Potential Anomalies"**

Remains Observation	Anomaly		
	Minor	Major	Critical
Requires no Specific Action	<p>Requires corrective action, but has no impact on:</p> <ul style="list-style-type: none"> <li>- Motor Performance</li> <li>- Program Schedule</li> </ul> <p>Does not reduce usability of part for its intended function</p> <p>Could cause damage preventing reuse of hardware in combination with other anomaly</p> <p>Significant departure from the historical database</p>	<p>Could cause failure in combination w/ other anomaly</p> <p>Could cause damage preventing reuse of hardware</p> <p>Program acceptance of cause, corrective action, and risk assessment required before subsequent static test or flight</p>	<p>Violates CEI Spec. requirements</p> <p>Could cause failure and possible loss of mission/life</p> <p>Mandatory resolution before subsequent static test/flight</p>
<p><b>Note:</b> These criteria to be applied to the specific observed "potential anomaly" as it relates to the observed article and as it relates to subsequent articles.</p>			

## 6.0 REFERENCES

1. G. A. Ricks, TWR-17543 vol. 1, "Flight Motor Set 360T004 (STS-30R) Final Report", Thiokol Corp., September 1989.
2. R. Ash, TWR-18760, Rev. A, "O-Ring Squeeze Calculations and Temperature Requirements 360T004", Morton Thiokol, Inc., February 1989.
3. C. D. Rice, TWR-18797, "Redesigned Solid Rocket Motor 360T004 Seal Leak Test Results", Morton Thiokol, Inc., March 1989.
4. Performance and Advanced Design, et. al., TWR-16475, Book 1, Volumes 1-9, "KSC Post-Flight Engineering Evaluation Plan", Morton Thiokol, Inc., 21 April 1989 (Vol. 4, Rev. D, Seals Component)
5. Performance and Advanced Design, et. al., TWR-16475, Book 2, Volumes. 1-9, "Clearfield Post-Flight Engineering Evaluation Plan", Morton Thiokol, Inc., 14 April 1989 (Vol. 4, Seals Component)



APPENDIX A  
RPRB PRESENTATIONS

REVISION \_\_\_\_\_

DOC NO.	TWR-17544	VOL IV
SEC	PAGE	

A-1

**PRESENTATION FOR  
OUTER IGNITER GASKET OF 360Q004A**

**24 MAY 1989**

**GEORGE ABAWI  
STRUCTURAL APPLICATIONS**

**(L224:FY89:P03)**

**TEAM RECOMMENDATION**

**Coordinated with Team Members:**

<b>Program Manager:</b>	<b>R. Brent Crosbie</b>
<b>Project Engineer</b>	<b>Kelly T. Kobayashi</b>
<b>Design Engineer</b>	<b>D. Gary Nelson, Lowell V. Nelsen, Chris D. Rlce</b>
<b>Systems Engineering:</b>	<b>Neal Townsend</b>
<b>Quality Assurance:</b>	<b>Karl Shupe</b>
<b>Reliability:</b>	<b>Jeff Richards</b>

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## PRESENTATION FOR OUTER IGNITER GASKET OF 360Q0004A

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### INTRODUCTION

This presentation is to inform the RPRB Board of the Post-flight inspection findings of the outer igniter gasket of 360H004 Left Hand Motor.

- o Observation Made at KSC
  - o Observation Categorized as "Potential Anomaly"
  - o "Potential Anomaly" Classified as "Major Anomaly"

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FORM 87-100-1 7-88

## PRESENTATION FOR OUTER IGNITER GASKET OF 360Q004A

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### BACKGROUND

### DESCRIPTION

- o The secondary seal of the outer gasket was found cut at 285 degrees. The cut exists at approximately 50 percent of the crown and extends radially inboard. Dimensions, approximately 0.10 inch long by 0.01 inch wide by 0.030 inch deep. (PR No. PV6-129207)

### HISTORY

- o No past history on this anomaly.
- o Outer gasket S/N 0000061 is a reused gasket, previously used on JES-3B.
- o Acceptance inspection criteria has been in accordance with STW7-2790.
- o Gasket was visually inspected prior to igniter installation. "QC, visually inspect the 1U51927-01 gasket for handling damage, (raised metal, seal damage etc.). No damage allowed".
- o Outer joint passed both the high and low pressure leak tests.

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## PRESENTATION FOR OUTER IGNITER GASKET OF 360Q004A

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### DR HISTORY

- o DR No. 151373 was written against two gouges in the metal retainer of the gasket at 230 and 284 degrees (11 May 1987).
- o Engineering disposition "Use As Is".

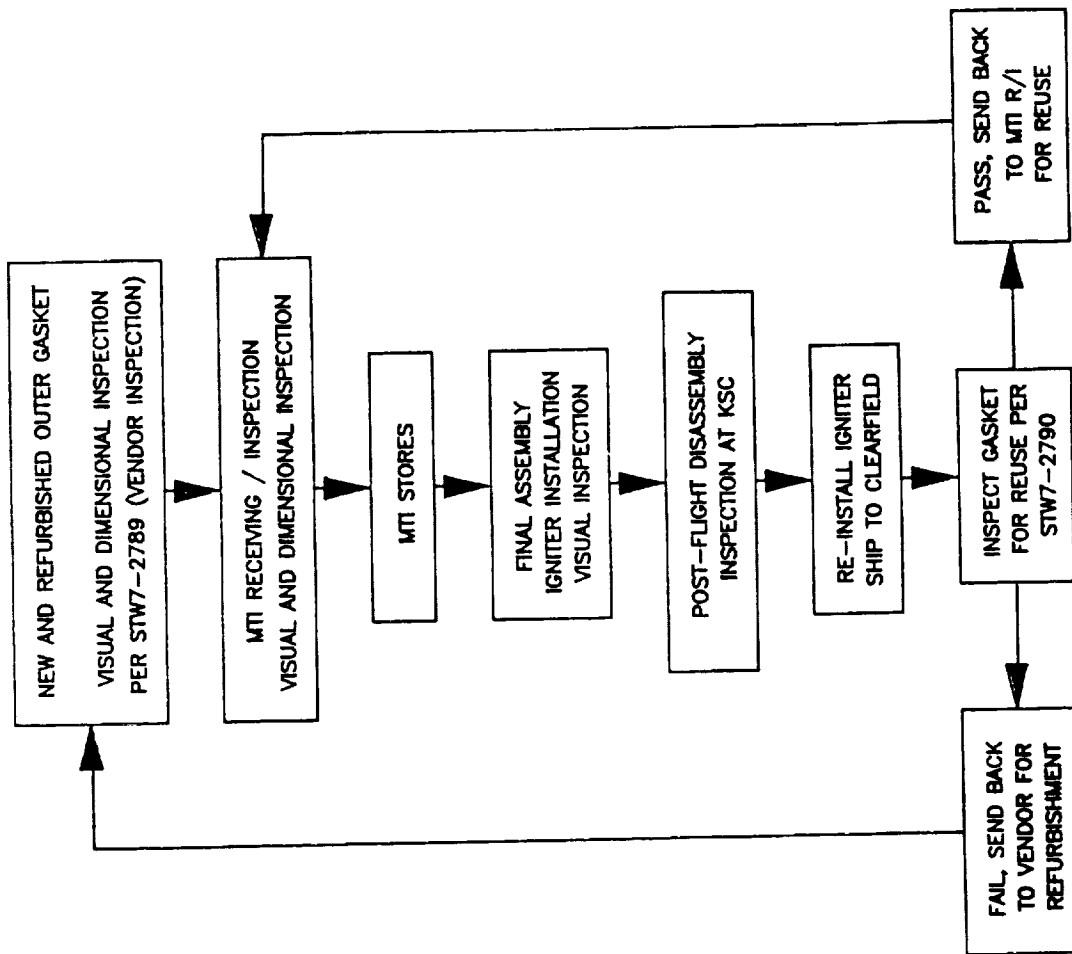
### OUTER GASKET FLAW TESTING

- o JES-3C and TPTA-2.2 outer gaskets were flawed.
- o One inch of the primary seal was removed.
- o Pressure to the secondary seal (JES - 945 psi, TPTA - 973 psi) disassembly inspection showed no damage to primary or secondary seals. No erosion or heat effect was found.

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## PRESENTATION FOR OUTER IGNITER GASKET OF 360Q004A

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### TEAM CLASSIFICATION

- o Major anomaly
  - o Program acceptance of cause, corrective action, and risk required before next flight.

### JUSTIFICATION

- o 360H005 and 360L006 igniter outer joints have passed leak test. If a leak path existed, it would have been found during leak tests.
- o New shipping, handling, and storage requirements have been implemented on all used gaskets of 360H005 and 360L006 (received from Clearfield; effective 7 December 1988).
- o Shipping, handling, and storage conditions of new and refurbished gaskets (received from vendor) are satisfactory.

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END OF PAGE 11

FLIGHT	S/N	REFU. NO.	USE NO.	LEAK RATE(SCCS) *		STOR REQ. USED GASKET
				1000 PSI	30 PSI	
1A	13	1	2	0.0018	-0.0001	NOT EFFECTIVE
1B	38	0	0	0.0022	-0.0007	N/A (VENDOR)
2A	30	1	0	-0.0031	0.0007	N/A (VENDOR)
2B	02	1	0	0.0077	0.0006	N/A (VENDOR)
3A	06	2	0	0.0018	-0.0003	N/A (VENDOR)
3B	04	1	3	-0.0092	-0.0001	NOT EFFECTIVE
4A	61	0	2	-0.0049	-0.0000	NOT EFFECTIVE 11/11/88
4B	16	1	0	0.0071	-0.0003	N/A (VENDOR)
5A	38	0	1	0.0007	-0.0001	EFFECTIVE 1/11/89
5B	34	1	2	0.0033	-0.0005	EFFECTIVE 2/28/89
6A	27	2	0	0.0036	-0.0003	N/A (VENDOR)
6B	22	2	0	0.0201	-0.0002	N/A (VENDOR)

\* HIGH PRESSURE AT 1000 PSI. MAXIMUM ALLOWABLE IS 0.1 SCCS  
LOW PRESSURE AT 30 PSI. MAXIMUM ALLOWABLE IS 0.0082 SCCS

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FORM 100-100-100



## PRESENTATION FOR OUTER IGNITER GASKET OF 360Q004A

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### RECOMMENDATIONS

- o Perform outer joint leak test using 360Q004A hardware.
- o Conduct gasket flaw and dynamic testing to evaluate the ability of the current leak check to detect various sizes of leak paths, in the presence of various types of anomalies across the seal.
- o Reinspect all available gaskets in Stores for similar anomalies.
- o Launch of Flights 5 and 6 should proceed as planned.

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PRESENTATION FOR OUTER IGNITER GASKET OF 360Q0004A

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RELIABILITY RECOMMENDATION

- o SPR already written - DR4-5/153

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## **RPRB PRESENTATION**

### **360T004A POST-FIRE ASSESSMENT SEALS COMPONENT INTERIM REPORT TEAM RECOMMENDATIONS**

**David Gurney  
L224:FY89:P02**

**31 May 1989**

**Coordinated With:**  
**PM - Brent Crosbie**  
**PM - Marcel Keanaaina**  
**PE - Kelly Kobayashi**  
**DE - Dan Pulleyn**  
**SE - Neil Townsend**  
**QA - Carl Shupe**  
**Reliability - Jeff Richards**

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## SEAL COMPONENT INTERIM REPORT - 360T004A (Continued)

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- INTRODUCTION

- EXTRUSION DAMAGE FOUND ON SECONDARY O-RING OF THE VENT PORT PLUG INSTALLED IN THE LEFT HAND CENTER FIELD JOINT (360T004A).

- CLASSIFICATION AND RECOMMENDATIONS WILL BE GIVEN

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# SEAL COMPONENT INTERIM REPORT - 360T004A (Continued)

## BACKGROUND

### PROBLEM REPORT

KSC PR NO. PV6-129276

### DESCRIPTION

SECONDARY O-RING FROM LEFT MOTOR, CTR FIELD JOINT, CUSTOM VENT PORT PLUG (1U76386-31) HAD EXTRUSION DAMAGE ON THE O.D. OF THE O-RING.

### HISTORY

EXTRUSION DAMAGE WAS FOUND ON:

- 360L001B NOZZLE-TO-CASE JOINT CUSTOM VENT PORT PLUG SECONDARY O-RING. CLASSIFIED AS "MINOR ANOMALY" 10 NOVEMBER 1988. CAUSED AT INSTALLATION.
- 360L003B AFT FIELD JOINT, CUSTOM VENT PORT PLUG (1U76386-32). CLASSIFIED AS "MINOR ANOMALY" 7 APRIL 1989. CAUSED BY AN OVERFILL CONDITION IN THE SHOULDER SEAL GLAND DUE TO A DIMENSIONALLY DISCREPANT PORT. REFERENCE DR 163057.

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# SEAL COMPONENT INTERIM REPORT - 360T004A (Continued)

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## CONCLUSION/RECOMMENDATIONS

### TEAM CLASSIFICATION

MINOR ANOMALY, NO CONSTRAINT FOR NEXT LAUNCH.

### RELIABILITY

SPR IS NOT BEING WRITTEN AT THIS TIME.

### RECOMMENDATIONS

REWORK 135 DEGREE PORT ON 1U52982-03 S/N 000034 CAPTURE FEATURE CYLINDER TO BLUEPRINT SPECIFICATIONS. REFERENCE DR 169706.

### JUSTIFICATION

EXTRUSION DAMAGE IS FROM AN O-RING OVERFILL CONDITION IN THE SHOULDER SEAL GLAND DUE TO A DIMENSIONALLY DISCREPANT PORT. REFERENCE DR 169706 and 163078. PLUG HEAD WAS VERIFIED TO BE FLUSH WITH THE SPOTFACE OF THE PORT. PASSED LEAK TEST.

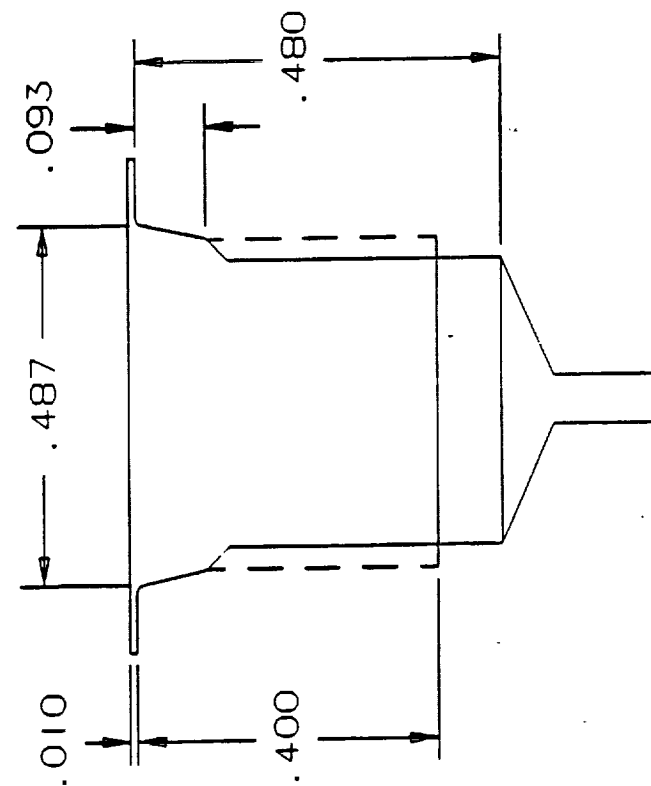
MORTON THIOKOL INC.

Aerospace Group

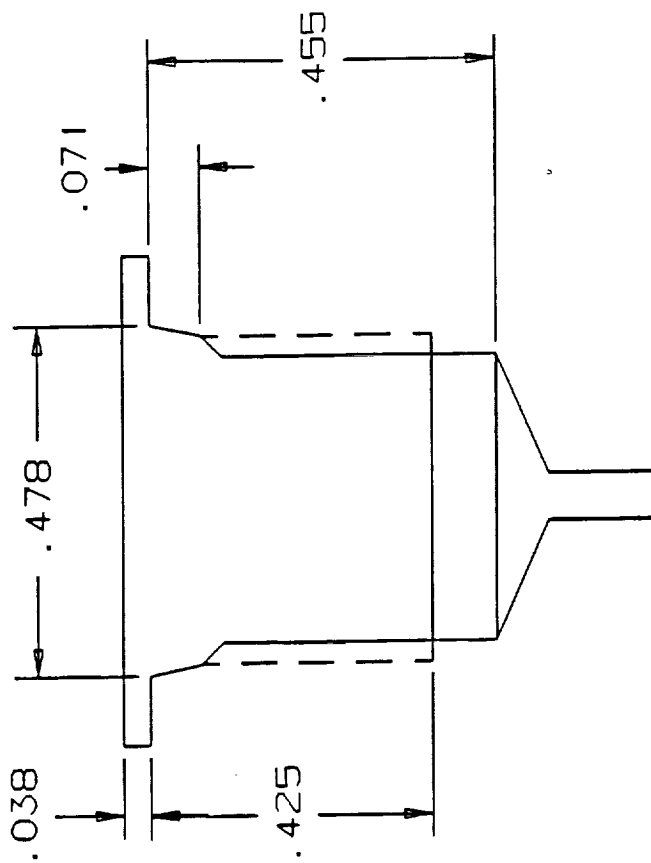
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DR 169706



PORT CONFIGURATION (Min)



EXISTING CONDITIONS

# **RPRB PRESENTATION**

**FOR**

## **4TH FLIGHT S&A DISASSEMBLY RESULTS**

**Bryan Spaulding**

Structural Applications  
(L224:FY90:P001)

19 JULY 1989

### **TEAM RECOMMENDATION**

**Coordinated with:**

PE	Tom M. Gregory
DE	Bryan C. Spaulding
DE	Doug G. Bullard
PM	W. Lynn Hankins
SE	W. Dave Starrett
REL	Jeff D. Richards
QA	Karl M. Shupe
PE	Kelly T. Kobayashi



# INTRODUCTION

This presentation will inform the RPRB members on the post-flight and test inspection findings concerning the Safe and Arm Device used on the 360L004 flight motors.

- Presentation states team findings, corrective actions, and flight 5 justification.
- Observations made during the H-7 (Clearfield) Seal Inspection.
- Observations categorized as "Potential Anomaly".
- "Potential Anomaly" classified as "Minor Anomaly".

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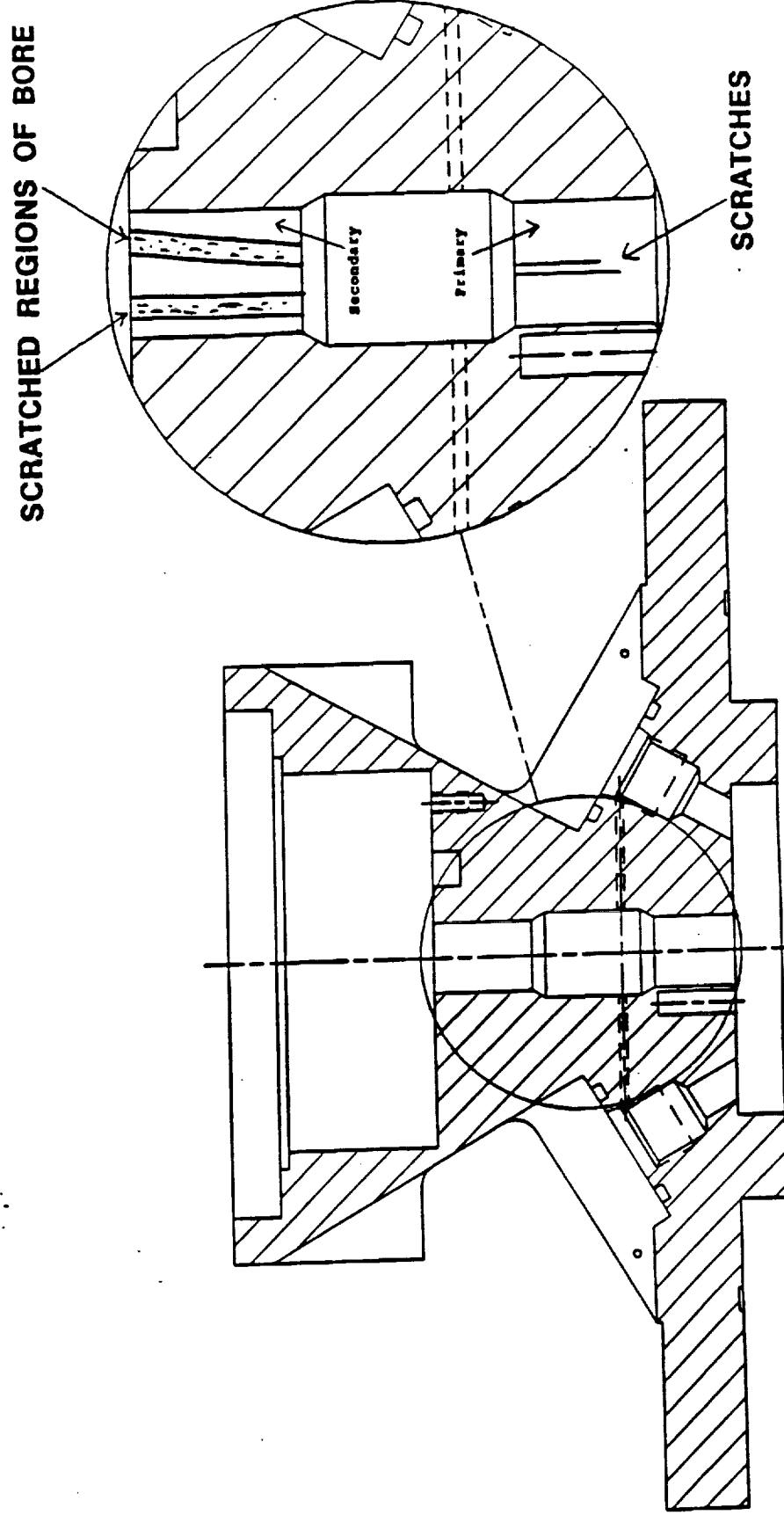
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# INTRODUCTION (Con't)

## PROBLEM DESCRIPTION

Scratches, found on 4th flight (360L004) Barrier-Booster housing bores, were not found prior to assembly.

- Units built after 4th flight could have unacceptable scratches.



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# BACKGROUND

## TEAM EVALUATION

Fourth flight (360L004) Safe and Arm Assemblies S/N 1 and S/N 4 were disassembled on 22 June 1989.

- Scratches were found on both of the Barrier-Boosters (B-Bs).
  - Serial number 1 and 4 had scratches on the rotor shaft housing bore sealing surfaces. These scratches had the same characteristics as three units previously found at our vendor ECC (Eaton Consolidated Controls).
  - Scratched ECC units were caused by the inspection tool (bore micrometer) used at ECC.
    - Reworked bore to eliminate scratches on the ECC units.
      - Rework procedure was successful.
  - Scratches of flight units were felt with a 5 and 10 mil brass shim stock.
- Maximum depth of scratches was 0.3 to 0.4 mils, including raised metal. Scratches ran up to the full length of the bore.

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## TEAM EVALUATION (Con't)

- Refurbishment specification STW7-3133, (Barrier-Booster Assembly Refurbishment and Acceptance Criteria for), requires all sealing surfaces be inspected for scratches.
  - Specifically calls out all sealing surfaces except for the B-B housing bore sealing surfaces.
  - ECC's operation and inspection plan does not call out the inspection of the bore sealing surfaces.
    - Planning references the sealing surface requirements sections of STW7-3133.

## HISTORY

- No past history on this anomaly.

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## TEAM CLASSIFICATION

- Remains minor anomaly, no constraint for flight 5.

## STS-28 JUSTIFICATION

- B-Bs are leak tested at 3168 and 50 psi.
  - 3168 psi--Tested twice in the safe position and once in the arm position.
    - Unit must pass leak test for acceptance.
    - NO LEAKAGE ALLOWED.
  - 50 psi--Tested once in the safe position.
    - Unit must pass leak test.
- Testing established that the 3168 psi leak test will pick up a 1 mil wire flaw at 13.0 percent squeeze.
  - Flight 5 squeeze ranges between 11 and 12 percent.

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## TO CLOSE PFAR

- Inspect all available units for possible scratches.
- Update STW7-3133 to call out the B-B housing bore inspection criteria.
- Review the ECC operation and inspection planning.
  - Modify ECC planning to call out sealing surface inspection criteria.
  - Review and update the baseline controls.
  - Train ECC inspection personnel on correct sealing surface inspection techniques.

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**RPRB PRESENTATION**  
**SEALS DISASSEMBLY REPORT**

**06 DECEMBER 1989**

**K. S. BAKER**  
**JOINTS AND SEALS DESIGN**

**PM: B. CROSBIE**  
**SIE: D. PULLEYN**  
**FP: D. STARRETT**  
**DE: K. BAKER, L. NELSEN, A. CARLISLE, G. ABAWI**  
**QE: P. FEARNES, L. ROBISON**  
**Rel: J. RICHARDS**

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■PFARs: 360T004A-20

■DESCRIPTION:

- A small piece of flashing was found to have been molded into the I.D. of the M83248/1 BB leak test port plug O-ring.

■HISTORY: Not previously seen on this O-ring; but this type of anomaly has been seen on other small O-rings.

■DISCUSSION:

- The BB assembly drawing calls out M83248/1 O-ring as the primary call out for the BB leak test port plug secondary seal
- The alternate call out is to use 1U50228 or 1U76145
- M83248/1 O-rings are not 100% inspected, lot acceptance is how they are received.
- 1U50228 is the current acceptable flight O-ring for all the other leak test port plug O-rings on the motor.
- 1U76145 drawing has been canceled.

■RECOMMENDATIONS:



■ TEAM CLASSIFICATION: Minor Anomaly

■ JUSTIFICATION:

■ This has no impact on motor performance because this is a packing seal and it does not experience any dynamic movement during motor operation.

■ CORRECTIVE ACTION:

- Short term; change assembly planning so that, were available, 1U50228 O-rings are used in the assembly of the S&A.
- Long term; remove all alternate O-rings from the three (1U52293, 294, and 295) assembly drawings and replace with the equivalent 1U50228 O-ring, except for environmental seals.

■ REPORT BACK TO RPRB? NO

■ ACTIONEE: S&A Component Program Team for actions 1&2.

■ PFARs: 360H005B-29, TEM04-02

■ DESCRIPTION:

■ Circumferential closed flow lines were found on two environmental seals of the S&A, the largest measured 0.120 inch long.

■ HISTORY: Not previously seen on these O-rings, but this type of anomaly has been seen on other small O-rings.

**■DISCUSSION:**

- Flow lines are caused during the molding process when the material introduced into the mold does not flow properly. Inherent to compression molding process.
- All the environmental seals in the S&A are Mil. Spec. O-rings which are not 100% inspected.

**■RECOMMENDATIONS:**

- **TEAM CLASSIFICATION:** Remains Observation

**■ JUSTIFICATION:**

- Environmental seals are designed to keep contamination out of the S&A under ambient conditions, flow lines on these O-rings will not impair this function because they close up when squeezed.

**■ CORRECTIVE ACTION:**

- Change Post Fire Engineering Evaluation Limits (PEEL) to say flow lines on the S&A environmental seals are acceptable.
- **REPORT BACK TO RPRB?** No
- **ACTIONEE:** Joints and Seals Design.

**■PFARs:** 360L003B-14

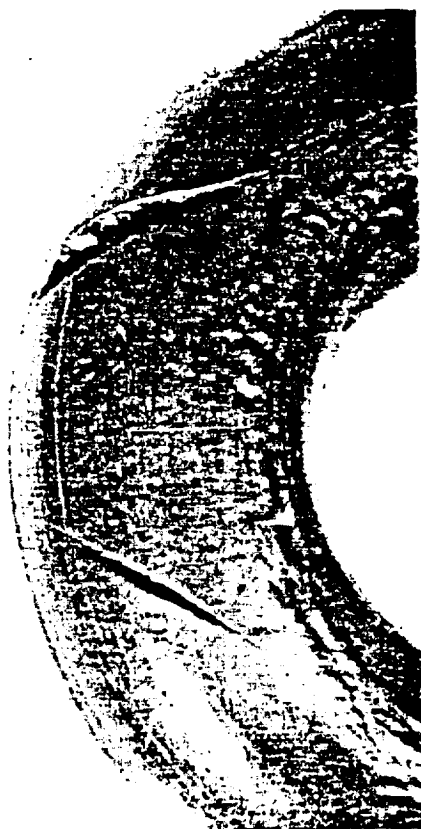
**■DESCRIPTION:**

- Two open radial flow lines were found on the forward field joint leak test port plug O-ring (lot 56). Approx. length of largest open flow line was 0.090 inch.

**■HISTORY:** Previously found on 1st flight center aft cyl. to cyl. factory joint.

- Presented to RPRB on 15 February 1989 with the following corrective action:
  - Dedicated 16 hole mold for 1U50228-15 O-ring starting with lot 47
  - Purged from stores all -15 O-rings prior to lot 47.
  - All -15 O-rings from lot 56 were re-inspected, none were found any anomalies.

SEALS DISASSEMBLY REPORT



360L003B FORWARD FIELD JOINT AT 45 DEG  
LEAK CHECK PLUG SECONDARY O-RING  
1U50228-15 ECL0056

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## SEALS DISASSEMBLY REPORT

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### ■DISCUSSION:

- Flow lines are caused during the molding process when the material introduced into the mold does not flow properly. Inherent to compression molding process.

### ■RECOMMENDATIONS:

- TEAM CLASSIFICATION: Minor Anomaly

### ■ JUSTIFICATION:

- This has no impact on motor performance because this is a packing seal and it does not experience any dynamic movement during motor operation.

### ■ CORRECTIVE ACTION:

- Implement the use the new base line O-ring material, STW4-3339.
- Implement new acceptance criteria for small O-rings, STW3-3744.
- Implement a dedicated O-ring molding area at the vendor
- Write a memo to Inspection personnel to alert them to this type of problem.

- REPORT BACK TO RPRB? yes

- ACTIONEE: O-ring Component Program Team for actions 1-3, Quality Engineering

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## SEALS DISASSEMBLY REPORT (Cont.)

for action 4.

■ PFARs: 360L006A-34

### ■ DESCRIPTION:

- A closed radial flow line was found on the 18 degree SII secondary O-ring of the LH motor.

■ HISTORY: Closed flow lines have previously found small O-ring but not on this particular part number.

### ■ DISCUSSION:

- This particular O-ring (1U52296) is not inspected to 1U50228 criteria.
- Flow lines are caused during the molding process when the material introduced into the mold does not flow properly. Inherent to compression molding process.

### ■ RECOMMENDATIONS:

- TEAM CLASSIFICATION: Minor Anomaly

### ■ JUSTIFICATION:

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## SEALS DISASSEMBLY REPORT (Cont.)

- This joint does not experience any dynamic movement, i.e. gap growth.
- This O-ring is leak tested at 50 psig which is designed to find O-ring flaws that would not seal during motor operation.
- CORRECTIVE ACTION:
  - Re-inspect all in-house 1U52296 O-rings to 1U50228 criteria.
  - Procure equivalent 1U50228 O-rings (-38).
  - Change assembly drawing to call out the 1U50228-38 O-ring (same corrective action as PFAR 360T004A-20).
- REPORT BACK TO RPRB?
- ACTIONEE: Quality Engineering for action 1, O-ring Component Program Team for action 2, S&A Component Program Team for action 3.

■PFARs: 360H005B-19

### ■DESCRIPTION:

- A small void was found in the O.D. of the S&A leak test port plug O-ring (1U50228-25, lot 19), measures approx. 0.05 inch in circumferential length by

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SEALS DISASSEMBLY REPORT (Cont.)

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0.015 inch wide radially by 0.003 inch deep

■HISTORY: Not previously seen.

■DISCUSSION:

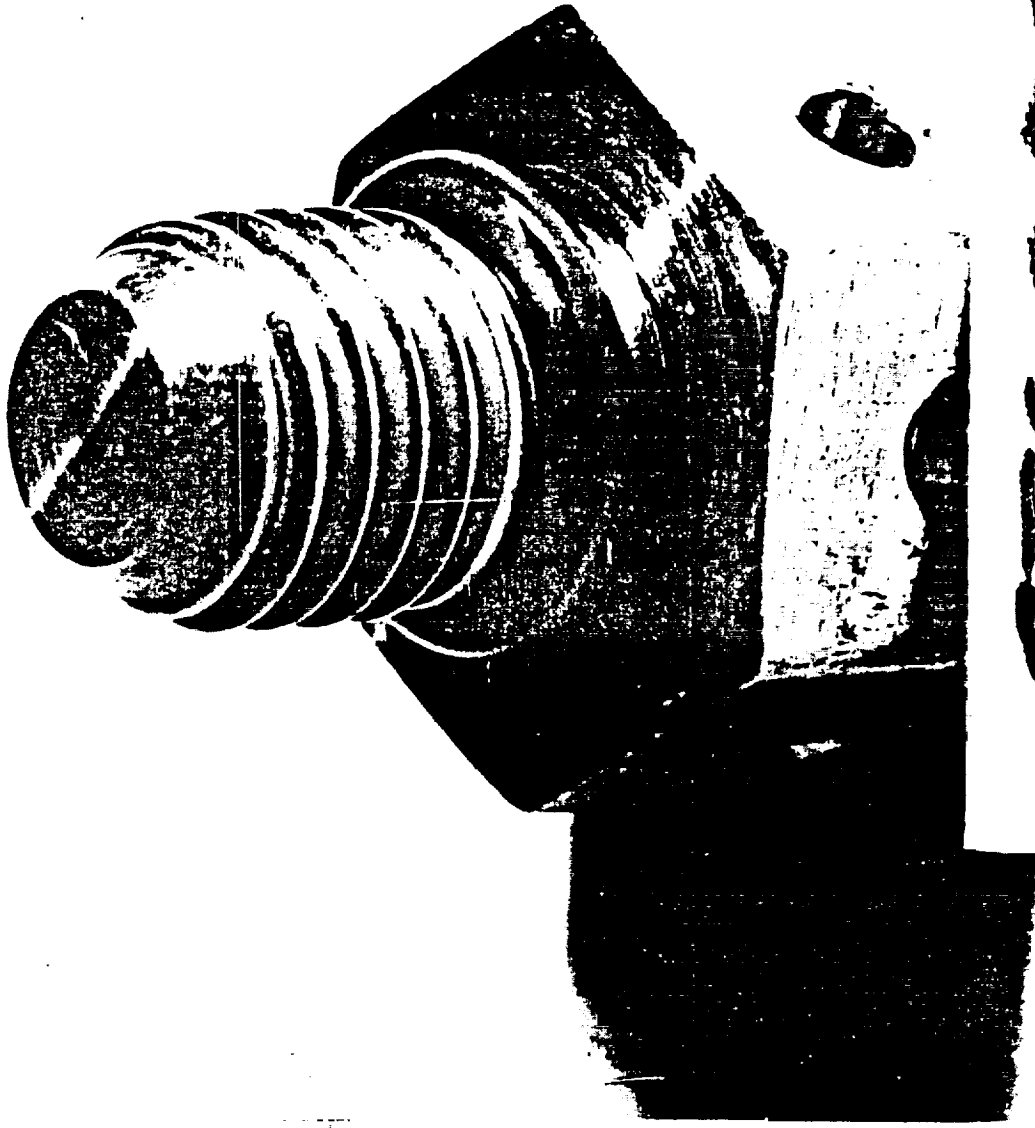
- Most probable cause is; the void was caused during the molding process.
- The material does not flow properly and causes trapped air pockets or no-fill areas before complete gland fill.

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## SEALS DISASSEMBLY REPORT



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## SEALS DISASSEMBLY REPORT

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### ■ RECOMMENDATIONS:

- TEAM CLASSIFICATION: Minor Anomaly

### ■ JUSTIFICATION:

- This has no impact on motor performance because this is a packing seal and it does not experience any dynamic movement during motor operation.

### ■ CORRECTIVE ACTION:

- Write a memo to inspection personnel to alert them to this type of problem.
- Implement actions 2-4 of PFAR 360L003B-14

### ■ REPORT BACK TO RPRB?

- ACTIONEE: Quality Engineering for action 1, O-ring Component Program Team for action 2.

■ PFARs: 360L006A-23, 360L006B-24

### ■ DESCRIPTION:

- The LH outer gasket environmental seal had intermittent shear separation

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## SEALS DISASSEMBLY REPORT (Cont.)

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around the edge of the retainer, largest separation measured approx. 2 inches long.

- The RH outer gasket environmental seal was sheared off the edge of the retainer from 175 to 320 degrees.

### REFERENCE: PFAR TEM02-01

■ **HISTORY:** Previously found on TEM-02 and TPTA 2.3, presented to RPRB on 28 July 1989.

- Recommendations from PFAR TEM02-01 have been incorporated into the baseline manufacturing plan at the vendor.
- Limits for acceptable damage to the environmental seal have been added to the PEEL, effective seventh flight.

### ■ **DISCUSSION:**

- This damage is probably the result of a combination of factors, they being:
  - Reuse of Gaskets, all four damaged environmental seals were on reused gaskets.
  - Long range program plan is to not refuse gaskets.
  - Possible contamination of the bondline with xylene primer (part of the cause

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## SEALS DISASSEMBLY REPORT (Cont.)

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of the TEM-02 problem).

- When a load is applied to the igniter adapter, during bolt pre-loading, a shearing action is applied to the seal at the O.D. of the gasket retainer.

### ■ RECOMMENDATIONS:

- TEAM CLASSIFICATION: Minor Anomaly

### ■ JUSTIFICATION:

- Even with the missing portion of the seal, their is still a portion of the seal still bonded to the lip of the retainer. With the remaining portion of the seal, the part still functions as intended.

### ■ CORRECTIVE ACTION:

- Close this PFAR.
- REPORT BACK TO RPRB? no
- ACTIONEE: Joints and Seals Design.

■ PFARs: 360L006B-33

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## SEALS DISASSEMBLY REPORT (Cont.)

### ■DESCRIPTION:

- Of the 100 packing with retainers from the RH motor, three had closed flow lines and three had open flow lines.

### REFERENCE: PFAR QM8-04

- HISTORY: First found on QM-8 and presented to RPRB on 8 March 1989 as a major anomaly.
- Presented to EMT for third flight as remains observation.
  - Corrective action from QM-8 had a flight effectivity of 6B.
    - All motors previous to 6B have been classified as remains observation.

### ■DISCUSSION:

- Flow lines are caused during the molding process when the material introduced into the mold does not flow properly. Inherent to compression molding process.
- MIL-STD-413 is the current inspection criteria for packing with retainers.
  - This standard was clarified and implemented for 6B.

### ■RECOMMENDATIONS:

- TEAM CLASSIFICATION: Minor Anomaly

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## SEALS DISASSEMBLY REPORT (Cont.)

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### ■ JUSTIFICATION:

- Testing done on packing with retainers with open flow lines from QM-8, has shown that they functioned as designed even with open flow lines.

### ■ CORRECTIVE ACTION:

- Write a memo to inspection personnel to alert them to this type of problem.
- Release packing with retainer acceptance specification (STW3-3780)
  - ECP-1974 in review at MSFC.
- Close this PFAR if no flow lines are found the seventh flight packing with retainers.
- REPORT BACK TO RPRB? yes, give results of seventh flight assessment.
- ACTIONEE: Quality Engineering for action 1, Joints and Seals Design for action 2.

■PFARs: 360L006A-32

### ■DESCRIPTION:

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## SEALS DISASSEMBLY REPORT (Cont.)

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- The secondary O-ring of dual seal plug that was used to plug the igniter pressure port had a I.D. cut, full circumference.

■HISTORY: Not previously seen.

### ■DISCUSSION:

- Most likely cause of this cut is from over fill of the dove tail groove on the dual seal plug.
  - Measurements of the O-ring, show it to be nominal size.
  - Actual plug was scraped during igniter adapter refurb.
    - This lot of plugs had a DR written against them for the dove tail groove being to shallow.
  - Removal of plug required approximately the same torque to remove as the comparable part in the RH motor.
    - Plug is lock wired in place.

■RECOMMENDATIONS: Classification and corrective actions will be determined by the Component Program Team.

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# RPRB PRESENTATION

## S&A DISASSEMBLY REPORT

10 JANUARY 1990

G. S. EDEN  
JOINTS AND SEALS DESIGN

PM: L. HANKINS, S. MEDRANO  
SIE: T. GREGORY  
FP: D. STARRETT  
DE: S. EDEN, D. BULLARD, K. BAKER  
QE: R. DAWES  
Rel: G. CONOVER

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OVERVIEW:

CLASSIFICATION

1- Copper particles on rotor shaft secondary O-rings	Minor Anomaly
2- Axial scratches across housing bore sealing surfaces	Minor Anomaly
3- Axial scratch on rotor shaft secondary O-ring groove	Minor Anomaly
4- Lack of/excess grease on leak test plug	Minor Anomaly
5- Galling on leak test plug shoulder seal surface	Minor Anomaly
6- Radial scratch across leak test plug seal surface	Minor Anomaly
7- Chipped thread on leak test plug	Minor Anomaly
8- Circ. scratch on shoulder seal surface of leak test port	Minor Anomaly
9- Contamination on shoulder seal surface of SII port	Remains observation
10- NSI/SII thread continuation into shoulder seal surface	Minor Anomaly
11- Radial scratch across shoulder seal surface of SII port	Minor Anomaly
12- Deformation in sealing washer of SII	Minor Anomaly
13- Radial scratch across sealing washer of SII	Minor Anomaly
14- Radial scratch across SII port secondary O-ring groove	Minor Anomaly

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## S&A DISASE ABLY REPORT

- PFARs: 360H005B-16, 360L006A-15, 360L006B-16

- DESCRIPTION:

- Small copper particles were found on the high pressure side of the rotor shaft secondary O-rings. Lab analysis confirmed the particles to be copper.

- HISTORY: First found on the 5B Barrier Booster. Similar particles were found on B-B's from 6A, and 6B. No contamination was found on 7A or 7B.

- DISCUSSION:

- The copper particles have only been found on the high pressure side of the rotor shaft secondary O-ring.

- The copper is being introduced into the leak test cavity in the rotor housing bore during the high pressure leak test at the vendor, Eaton Valve and Actuator Division (E-VAD).

- A copper Conoseal is used in the connection between the pressure line and the leak test port adapter. Conoseals from the line were inspected and found to be flaking under use.

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■ DISCUSSION (cont.)

- The copper particles come in contact with the secondary O-rings when the rotor shaft is removed from the housing bore; the O-rings wipe the grease and copper from the bore as it passes through.

■ RECOMMENDATIONS:

- TEAM CLASSIFICATION: Minor Anomaly

■ JUSTIFICATION:

- Violates engineering and requires corrective action.
- Has no impact on motor performance because:
  - The rotor shaft is installed into the housing bore before leak testing is performed,
  - The rotor shaft seals passed two high pressure and one low pressure leak test.

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## S&A DISASSEMBLY REPORT

### ■ CORRECTIVE ACTION:

- Short term: Add E-VAD planning change to blow the pressure line clean prior to each hook-up.
  - Implement an in-line filter in the leak test equipment to prevent any contamination from entering the bore.  
Effective: 19 January 1990.
- Long term: Modify the 8U leak test equipment to replace all copper fittings.
- REPORT BACK TO RPRB? No
- ACTIONEE: S&A Component Team for short term, Joints and Seals Design for long term.

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## S&A DISASS MBL Y REPORT

PFARs: 360T004A-18, 360T004B-19, 360H005A-14, 360H005B-15, TEM04-11,  
LAT41-04

### DESCRIPTION:

- Several axial scratches were found across the B-B rotor shaft housing bore primary and secondary seal surfaces. The scratches vary in length and have a maximum depth of approximately 0.4 mils.

▪ HISTORY: No history of scratches in the housing bore previous to 360T004 have been reported.

### DISCUSSION:

- The housing bore is made of soft material (304 Stainless) and is easily scratched.
- The most probable cause of the scratches is the bore measurement inspection tool.
- Up to Sixth Flight, E-VAD's planning did not require inspection of the bore after bore measurement.

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## S&A DISASSEMBLY REPORT

- DISCUSSION (cont.)
  - The refurbishment specification, STW7-3133, does not specifically call out inspection point for the housing bore.
- RECOMMENDATIONS:
  - TEAM CLASSIFICATION: Minor Anomaly
  - JUSTIFICATION:
    - Violates engineering and requires corrective action.
    - B-B's with scratched bores have passed the high and low pressure leak tests.
    - Post-fire inspection found no damage to the rotor shaft O-rings.
  - CORRECTIVE ACTION:
    - Short Term: Modify vendor planning to inspect all B-B rotor housing bore seal surfaces for damage prior to rotor installation.

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## S&A DISASS /BLY REPORT

- CORRECTIVE ACTION (cont.)
  - Short Term:
    - OCR implemented- Effective: Sixth Flight.
    - Long Term: Replace bore measurement inspection tool with air micrometer.
    - Update refurbishment specification, STW7-3133, to incorporate better seal surface definitions and inspection points.
  - REPORT BACK TO RPRB? No
  - ACTIONEE: S&A Component Team and Joints and Seals Design.

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# S&A DISASSSEMBLY REPORT

■ PFARs: TEM04-03

■ DESCRIPTION:

- Small axial scratch found on B-B rotor shaft secondary O-ring groove; approximate length was 30 mils.

■ HISTORY: Not previously reported.

■ DISCUSSION:

- Occurrence unknown; scratch probably occurred at O-ring removal during refurbishment.

■ RECOMMENDATIONS:

■ TEAM CLASSIFICATION: Minor Anomaly

■ JUSTIFICATION:

- Violates engineering and requires corrective action.
- The rotor shaft seals passed both high and low pressure leak tests.

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# S&A DISASSEMBLY REPORT

## ■ JUSTIFICATION (cont.):

- No rotor shaft O-ring damage has been found due to scratches in the housing bore: *rotor shaft O-ring groove.*

## ■ CORRECTIVE ACTION:

- Short Term: Clarify inspection point of the rotor shaft O-ring groove seal surfaces in vendor (E-VAD) planning.
- Implement non-metallic O-ring removal tool in all places that require removal of O-rings. Effective: 19 January 1990
- Long Term: Update refurbishment specification, STW7-3133, to incorporate better seal surface definitions and inspection points.

## ■ REPORT BACK TO RPRB? No

## ■ ACTIONEE: S&A Component Team and Joints and Seals Design.

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## S&A DISASSEMBLY REPORT

- PFARs: 360L001A-48, 360L003B-15, 360H005A-17, 360H005B-18, 360H005B-31, TEM04-04, LAT41-02

- DESCRIPTION:

- Lack of/excess grease found on S&A leak test (MS9902-01) plugs.

- HISTORY: First, Third, and Fifth Flights, TEM-04, and LAT-41.

- DISCUSSION:

- Thiokol planning does not specify amount of grease to be applied to B-B leak test plug or O-ring.
  - KSC planning (OMI) did not require grease application to the S&A-to-adaptor leak test plug or O-ring prior to Sixth Flight.
    - OMI update for proper grease application effective Sixth Flight.
  - Grease is used as a lubricant for the O-ring; a lack of grease could damage the O-ring upon assembly and excess grease could cause an overfill condition and result in O-ring extrusion damage.

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SPACE OPERATIONS

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# S&A DISASSSEMBLY REPORT

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## ■ RECOMMENDATIONS:

- TEAM CLASSIFICATION: Minor Anomaly

## ■ JUSTIFICATION:

- Potential for O-ring damage.
- Corrective action is required.
- No O-ring damage has been found due to a lack of or excessive grease on the MS9902-01 leak test plug.

## ■ CORRECTIVE ACTION:

- Short Term: Update Thiokol planning to quantify grease application to the leak test plugs and O-rings. Effective: 19 January 1990

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## S&A DISASS( BLY REPORT

- CORRECTIVE ACTION (cont.):
  - Long Term: Implement TRACS at Thiokol and KSC for proper grease application techniques and update the grease spec to incorporate small O-rings.
  - Add limits to PEEL stating lack of/excessive grease is reportable.
  - Modify grease specification, STW7-2999, to incorporate small O-ring grease application.
- REPORT BACK TO RPRB? No
- ACTIONEE: Joints and Seals Design and Final Assembly Work Center.

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## S&A DISASSSEMBLY REPORT

- PFARS: 360T004B-25, 360L006A-31, 360L006B-32, 360L007A-19, 360L007B-20, TEM04-06, LAT41-03
- DESCRIPTION:
  - Circumferential galling was found on the shoulder seal surface of the S&A-to-adaptor and B-B bore leak test (MS9902-01) plugs. The width and length of the galled region varies.
- HISTORY: Not previously reported.
- DISCUSSION:
  - Galling on the plug occurs during the machining process of the seal surface on the plug.
  - The leak test plugs are inspected and installed into the B-B at E-VAD. They are removed prior to leak test and re-installed on plant (B-B bore) and at KSC (flange).
  - Thiokol assembly planning does not call out inspection of the B-B bore leak test plug prior to re-installation.

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# S&A DISASSEMBLY REPORT

## ■ RECOMMENDATIONS:

- TEAM CLASSIFICATION: Minor Anomaly

## ■ JUSTIFICATION:

- Violates surface finish and requires corrective action.
- Shoulder seal is a packing rather than a face seal.
- Galled surface does not extend across the full O-ring footprint.
- No O-ring damage has been found due to galled shoulder seal surface of leak test plug.

## ■ CORRECTIVE ACTION:

- Short Term: Inspect all MS9902-01 plugs in Stores and at E-VAD per MS9902 specification and reject those that are unacceptable.  
Effective: 19 January 1990.

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## S&A DISASSEMBLY REPORT

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- CORRECTIVE ACTION (cont.):
  - Long Term: Replace MS9902-01 plug with 1U50159 leak test plug; 1U50159 plugs are 100 percent inspected and controlled in-house.
- REPORT BACK TO RPRB? No
- ACTIONEE: Quality Engineering for short term and S&A Component Team for long term.

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# S&A DISASSEMBLY REPORT

- PFARs: LAT41-01, TEM04-05.
- DESCRIPTION:
  - A single radial scratch was found across the shoulder seal surface of the S&A-to-adapter and B-B bore leak test (MS9902-01) plugs.
- HISTORY: Previously found on Second and Third Flights.
- DISCUSSION:
  - The assembly/leak test procedure for the S&A requires that the leak test plug be removed from the port prior to leak test of the seals. The old O-ring is to be removed from the plug. A new O-ring is to be installed onto the plug prior to plug re-installation.
  - Up to, but not including Fifth Flight, the tool used to remove the O-rings was causing the scratch across the seal surface of the plug.
  - Inspection of the seal surface was not being properly performed prior to plug re-installation.

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## S&A DISASSEMBLY REPORT

### ■ DISCUSSION (cont.):

- PFAR's from Second and Third Flights were closed out by updating planning and using non-metallic removal tool for O-rings.
- Corrective action became effective for Fifth Flight.

### ■ RECOMMENDATIONS:

- TEAM CLASSIFICATION: Minor Anomaly

### ■ JUSTIFICATION:

- Violates PEEL; assembly metal damage is reportable.
- No O-ring damage has been found due to scratch on plug.
- Shoulder O-ring is a packing seal.
- High installation torque ensures metal-to-metal seating of plug to port spotface.

*Thiokol* CORPORATION  
SPACE OPERATIONS

## S&A DISASSSEMBLY REPORT

- **CORRECTIVE ACTION:**

- **SHORT TERM:** Modify vendor and Thiokol planning to properly inspect leak test plug seal surface prior to plug installation.  
Effective: 19 January 1990.

- **REPORT BACK TO RPRB?** No

- **ACTIONEE:** Quality Engineering and Joints and Seals Design

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## S&A DISASSEMBLY REPORT

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- PFARs: 360L006A-21

- DESCRIPTION:

- The last thread of the S&A-to-adapter and B-B bore leak test (MS9902-01) plugs was chipped.

- HISTORY: Not previously reported.

- DISCUSSION:

- The thread becomes chipped during the machining process; a portion of the thread shears off.

- The MS9902-01 leak test plugs are lot accepted.

- The chipped thread could damage the O-ring upon assembly.

- The Thiokol assembly planning does not require the use of a thread protector to install the O-ring onto the plug.

*Thiokol* CORPORATION  
SPACE OPERATIONS

## S&A DISAST MBL Y REPORT

### ■ RECOMMENDATIONS:

- TEAM CLASSIFICATION: Minor Anomaly

### ■ JUSTIFICATION:

- This is the first time a chipped thread on a (MS9902) leak test plug has been reported.
- Requires corrective action.
- No O-ring damage has been found due to chipped thread.

### ■ CORRECTIVE ACTION:

- Short Term: Inspect all MS9902-01 plugs in Stores and at E-VAD per MS9902 specification and reject those that are unacceptable.
- Implement thread protector. Effective: 19 January 1990.

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## S&A DISASSEMBLY REPORT

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- CORRECTIVE ACTION (cont.)

- Long Term: Replace MS9902-01 plug with 1U50159 leak test plug; 1U50159 plugs are 100 percent inspected and controlled in-house.
- Add PEEL criteria stating chipped threads are reportable.

- REPORT BACK TO RPRB? No

- ACTIONEE: Quality Engineering for short term and S&A Component Team for long term.

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# S&A DISASSY MBLY REPORT

■ PFARs: 360L007A-22, 360L007B-23

■ DESCRIPTION:

- A single circumferential scratch was found on the shoulder seal area of the S&A-to-adapter and B-B bore leak test ports.

■ HISTORY: Not previously reported.

■ DISCUSSION:

- The scratch occurred prior to leak test plug installation. The scratch is visible with good lighting and should have been found during inspection.
- Thiokol assembly planning does not call out an inspection point for the B-B bore leak test plug port seal surfaces.
- The Barrier Booster refurbishment specification (STW7-3133) does not allow any seal surface defects.

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## S&A DISASSSEMBLY REPORT

### ■ RECOMMENDATIONS:

- TEAM CLASSIFICATION: Minor Anomaly

### ■ JUSTIFICATION:

- Violates engineering and requires corrective action.
- The scratch is in the circumferential direction and does not cross the O-ring footprint.
- The shoulder O-ring is a packing seal.
- No O-ring damage has been found due to scratch in leak test port.

### ■ CORRECTIVE ACTION:

- Short Term: Update Thiokol assembly planning and vendor refurb planning to perform detailed inspection of all port seal surfaces.  
Effective: 19 January 1990.

*Thiokol* CORPORATION  
SPACE OPERATIONS

## S&A DISASS( 1BLY REPORT

- CORRECTIVE ACTION (cont.):
  - Long Term: Modify refurbishment specification, STW7-3133, to incorporate better seal surface definitions and inspection points.
- REPORT BACK TO RPRB? No
- ACTIONEE: S&A Component Team and Joints and Seals Design.

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## S&A DISASS( )BLY REPORT

■ PFARs: 360L006A-31, 360L007B-21

■ DESCRIPTION:

- A black substance was found in the grease on the primary seal surface of the SII port.

■ HISTORY: Not previously reported.

■ DISCUSSION:

- Lab analysis identified black substance as combustion products from SII.
- Source of contamination was found to be introduced during removal of the SII at disassembly.
- Combustion products in the sooted tip of the SII rubbed off into the grease as the SII was removed.

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## S&A DISASSSEMBLY REPORT

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- **RECOMMENDATIONS:**

- **TEAM CLASSIFICATION:** Remains observation.

- **JUSTIFICATION:**

- Non-problem and does not require corrective action.

- **RECOMMENDATIONS:**

- Close PFARs.

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## S&A DISASSY 'BLY REPORT

- PFARs: 360L006A-19, 360L006B-20, TEM04-08, TEM04-10
- DESCRIPTION:
  - NSI/SII thread was found to continue into the primary seal surface.
- HISTORY: Previously found on NSI/SII's all the way back into the SRM program.
- DISCUSSION:
  - The NSI/SII is a NASA controlled part; the drawing does not control the thread termination point.
    - An industry alert was submitted in January 1989 stating that the threads may possibly continue up to the body and leave no viable seal surface. A recommendation for a specification change was made.
  - The alert was stopped by NASA.
- RECOMMENDATIONS:
  - TEAM CLASSIFICATION: Minor Anomaly

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SPACE OPERATIONS

# S&A DISASSEMBLY REPORT

## ■ JUSTIFICATION:

- Potential to violate seal surface and requires corrective action.
- No history of thread continuation past O-ring footprint; two other seal surfaces remain.
- Sll's are low pressure leak tested; no leaks were detected.
- No primary O-ring damage has been found due to thread continuation.

## ■ CORRECTIVE ACTION:

- Short Term: Inspect all Sll's in Stores for continuation of threads.
- Update planning to inspect for continuation of threads into seal surface prior to installation.  
Effective: 19 January 1990.

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SPACE OPERATIONS

## S&A DISASS'IBLY REPORT

- **CORRECTIVE ACTION (cont.):**

- Long Term: Recommend and submit engineering changes for a unibody SII, including industry standard thread relief, to NASA.
- Add PEEL limits stating threads continuing into seal surface is reportable.

- **REPORT BACK TO RPRB? No**

- **ACTIONEE: S&A Component Team and Joints and Seals Design.**

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# S&A DISASS /BLY REPORT

- PFARs: 360L006A-27, 360L006B-28

- DESCRIPTION:

- A single radial scratch was found across the primary (shoulder) seal surface of the SII port.

- HISTORY: Not previously reported.

- DISCUSSION:

- The scratch occurred prior to SII installation. The scratch is visible with good lighting and should have been found during inspection.
- Thiokol assembly planning does not call out an inspection point for the SII port seal surfaces.
- The Barrier Booster refurbishment specification (STW7-3133) does not allow primary seal surface defects.

- RECOMMENDATIONS:

- TEAM CLASSIFICATION: Minor Anomaly

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## S&A DISASSEMBLY REPORT

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- JUSTIFICATION:

- Violates engineering and requires corrective action.
- The SII's are low pressure leak tested; no leaks were detected.
- The primary O-ring is a packing seal.
- Evidence of soot to the primary O-ring has not been reported.
- No O-ring damage has been found due to scratch in port.

- CORRECTIVE ACTION:

- Short Term: Update Thiokol assembly planning and vendor refurb planning to include detailed inspection of all port seal surfaces.  
Effective: 19 January 1990.

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## S&A DISASSEMBLY REPORT

- **CORRECTIVE ACTION (cont.):**

- Long Term: Update refurbishment specification, STW7-3133, to incorporate better seal surface definitions and inspection points.
- Incorporate test plan to evaluate the SII leak test.
- **REPORT BACK TO RPRB? No**
- **ACTIONEE: S&A Component Team and Joints and Seals Design.**

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## S&A DISASSEMBLY REPORT

- PFARs: 360H005A-22, 360H005A-23, 360H005B-24, 360H005B-25, 360L006A-17, 360L006B-18, 360L007A-15, 360L007B-16, TEM04-07, TEM04-08
- DESCRIPTION:
  - Several deformations were found in the sealing washer on the SII's. The deformations are circumferential and follow the pattern of the NSI. The largest deformations, located over the wrench slots, are approximately 3 mils deep.
- HISTORY: Previously found at post-fire inspection since TEM-04. Deformations have been noticed since SII Lot HWD and subsequent.
- DISCUSSION:
  - The NSI/SII is a government furnished part.
    - The SII is created by welding a back-up ring to the NSI which provides a secondary seal surface. A sealing washer is then welded on to provide the actual seal surface and to compensate for irregularity in the NSI/back-up ring interface.
  - The washer is deformed during manufacturing process.

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# S&A DISASSEMBLY REPORT

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## ■ RECOMMENDATIONS:

- TEAM CLASSIFICATION: Minor Anomaly

## ■ JUSTIFICATION:

- Potential to violate O-ring squeeze and requires corrective action.
- Deformation does not completely compromise secondary O-ring footprint.
- The SII's are low pressure leak tested; no leaks were detected.

## ■ CORRECTIVE ACTION:

- Short Term: Investigate engineering accept/reject criteria of deformations.
- Add inspection point during acceptance to screen out-of-tolerance deformations.  
Effective: 19 January 1990.

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SPACE OPERATIONS

## S&A DISASSEMBLY REPORT

- CORRECTIVE ACTION (cont.):

- Long Term: Recommend and submit engineering changes to NASA for a unibody construction for the SII.
- Add PEEL limits stating that deformations in sealing washer are reportable.
- Evaluate new design for larger secondary O-ring and groove for higher squeeze.
- Incorporate test plan to evaluate the SII leak test.
- REPORT BACK TO RPRB? Yes
- ACTIONEE: NASA, S&A Component Team, and Joints and Seals Design.

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## S&A DISASSEMBLY REPORT

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- PFARs: 360L006A-25, 360L007B-18
- DESCRIPTION:
  - A single radial scratch was found across the sealing washer of the SII. The maximum depth of the worst case scratch was less than 1.0 mil.
- HISTORY: Not previously reported.
- DISCUSSION:
  - Thiokol assembly planning has an inspection point to verify no damage to the SII's: no scratches, nicks, dings, etc.
  - The scratches occur prior to SII assembly; source is unknown.
- RECOMMENDATIONS:
  - TEAM CLASSIFICATION: Minor Anomaly

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## S&A DISASSEMBLY REPORT

- JUSTIFICATION:

- First time occurrence, is reportable, and requires corrective action.
- The SII's are low pressure leak tested; no leaks were detected.
- No secondary O-ring damage has been found due to the scratch across the seal washer.

- CORRECTIVE ACTION:

- Short Term: Update Thiokol assembly log to include detailed inspection of SII seal surfaces; replace those that are unacceptable. Effective: 19 January 1990.
- Long Term: Recommend and submit engineering changes to NASA for unibody SII.
- Incorporate test plan to evaluate the SII leak test.

- REPORT BACK TO RPRB? No

- ACTIONEE: S&A Component Team, Joints and Seals Design, and NASA.

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## S&A DISASSEMBLY REPORT

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- PFARs: 360L006A-26, 360L007A-17

- DESCRIPTION:

- A single radial scratch was found across the bottom of the SII secondary O-ring groove.

- HISTORY: Not previously reported.

- DISCUSSION:

- The scratch occurred prior to SII installation. The scratch is visible in good lighting and should not have been missed during inspection.
- Thiokol assembly planning does not call out an inspection point for the SII port seal surfaces.
- The Barrier Booster refurbishment specification (STW7-3133) does not allow secondary seal surface defects in ports.

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# S&A DISASSEMBLY REPORT

## ■ RECOMMENDATIONS:

- TEAM CLASSIFICATION: Minor Anomaly

## ■ JUSTIFICATION:

- Violates engineering and requires corrective action.
- The SII's are low pressure leak tested; no leaks were detected.
- No primary O-ring damage has been found due to scratch in shoulder seal surface of port.

## ■ CORRECTIVE ACTION:

- Short Term: Update Thiokol assembly planning and vendor refurb planning to perform detailed inspection of all port seal surfaces.  
Effective: 19 January 1990.

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## S&A DISASSEMBLY REPORT

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- **CORRECTIVE ACTION (cont.):**

- Long Term: Update refurbishment specification, STW7-3133, to incorporate better seal surface definitions and inspection points.
- Incorporate test plan to evaluate the SII leak test.

- **REPORT BACK TO RPRB? No**

- **ACTIONEE: S&A Component Team and Joints and Seals Design.**

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**RPRB PRESENTATION**

**POST-FIRE ANOMALIES**  
**SEALS COMPONENT REPORT**  
**TEAM RECOMMENDATIONS**

**DAVID GURNEY**

**14 FEBRUARY 1990**

**Coordinated With:**

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## POST FIRE ANOMALIES

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- PFARs: 360L003A-20, 360L003B-21, 360T004A-22, 360T004B-23, 360H005A-27, 360H005B-28, 360L006A-35, 360L006B-36
- DESCRIPTION:
  - No grease on port, plug, and O-ring
- HISTORY:
  - Similar problems previously reported to RPRB on 18 April 1989
  - Corrective actions implemented:
    - Planning has been updated to include greasing, but will not become totally effective until 10th flight.
    - Drawings have been changed to call out the proper installation specification.
  - Previously classified as Minor Anomaly

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## POST FIRE ANOMALIES

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- **RECOMMENDATIONS:**
- **TEAM CLASSIFICATION:** Minor Anomaly
- **JUSTIFICATION:**
  - Violates engineering, does not require any new corrective action, and has no impact on motor performance because:
    - The O-ring will seal properly with no grease
    - The plugs are verified to be flush with the case
    - Does not reduce usability of plug for its intended function.
- **CLOSE ALL PFARS**
- **CORRECTIVE ACTION:** Already implemented, no additional action required.
- **REPORT BACK TO RPRB?** No

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## POST FIRE ANOMALIES

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- PFARs: 360L001B-50, 360L002A-34, 360L002A-35, 360L002B-33, 360L003A-18, 360L003B-19, 360T004A-26, 360T004B-20, 360L004B-21, 360L005A-23, 360L005B-24, 360L006B-24, 360L007A-28
- DESCRIPTION:
  - Rolled threads on last partial thread of 1U51475 & 1U100269 leak check plugs
- HISTORY:
  - Occurred on RSRM-1, and RSRM-2 for the 1U100269 plug and was reported to RPRB on 1 March 1989.

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## POST FIRE ANOMALIES

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- Corrective actions (Completed) were to:
  - Inspect plugs in house for rolled threads
  - Discuss problems with the vendor to correct the problems on future hardware.
  - Release ECO to prohibit rolled threads
  - Complete the implementation of O-ring installation aid and plug thread inspection in Shop Planning
- DISCUSSION:
  - O-ring cannot be damaged during assembly because it is assembled over the O-ring installation aid.
  - Once installed, the O-ring will not contact the threads of the plugs.
  - During disassembly, the O-ring is typically cut on the inner diameter as the plug rotates out.

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## POST FIRE ANOMALIES

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- RECOMMENDATIONS:
  - TEAM CLASSIFICATION: Remains Observation
  - JUSTIFICATION:
    - This problem does not require any new corrective action.
    - The O-ring will not be damaged on assembly.
    - This will not affect the installation of the plug
  - CORRECTIVE ACTION: Joints and Seals/Post Fire Evaluation to update the peel document to allow this situation on disassembly.
- CLOSE PFARs
- REPORT BACK TO RPRB? No

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## POST FIRE ANOMALIES

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- PFARs: 360H005B-25, 360L006B-22, 360L007A-27
- DESCRIPTION:
  - Radial scratches on the secondary seal surface of leak check plugs (1U51475 & 1U100269)
- DISCUSSION
  - Source of the scratch is believed to be handling damage after the inspection of the plugs.
  - The 1U51475-01 plugs are made from a 1U100269-01 plug.
  - A baseline now controls the handling and processing of the 1U100269 plugs.

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## POST FIRE ANOMALIES

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- RECOMMENDATIONS
- TEAM CLASSIFICATION: Minor Anomaly
- JUSTIFICATION:
  - Violates engineering and requires corrective action.
  - Potential leak path
  - Potential damage to O-ring, causing leak path
- CORRECTIVE ACTION: Program Management to write an AO to inspect plugs in house for this defect that were made after the last inspection, and before the baseline was established. Quality Engineering to write the planning for this inspection. Quality Engineering to take steps to prevent future occurrences of this problem.
- REPORT BACK TO RPRB? No

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## POST FIRE ANOMALIES

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- PFARs: 360H005A-26
- DESCRIPTION:
  - Circumferential scratch on dovetail of adjustable vent port plug (1U76425)
- DISCUSSION:
  - The scratch is a machining mark.
- HISTORY
  - First occurrence of this problem

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## POST FLIGHT ANOMALIES

- RECOMMENDATIONS
- TEAM CLASSIFICATION: Minor Anomaly
- JUSTIFICATION:
  - Violates engineering and requires corrective action.
  - Scratch is circumferential, and does not go across the footprint of the O-ring.
  - The O-ring in this area is a packing seal, and will tolerate this type of defect.
  - The O-rings of this plug are leak tested.
  - Circumferential tooling marks are allowed on the mating surface.
  - No structural concerns

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## POST FIRE ANOMALIES

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- CORRECTIVE ACTION: Quality Engineering to train inspectors to find this problem.
- REPORT BACK TO RPRB? No

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# POST FIRE ANOMALIES

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- PFARs: 360H005B-32
- DESCRIPTION:
  - Raised metal in the first internal thread of the Adjustable Vent Port Plug (1U76425-03).
- DISCUSSION:
  - The raised metal is believed to have been caused by slightly cross threading either the leak test adapter or Closure Plug into these threads.
- HISTORY
  - First occurrence of this problem

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## POST FIRE ANOMALIES

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- RECOMMENDATIONS
- TEAM CLASSIFICATION: Minor Anomaly
- JUSTIFICATION:
  - The Closure Plug is verified to be flush at installation.
  - Running and final torque values controlled
  - Threads are inspected prior to installation of the Closure Plug.
- CORRECTIVE ACTION: Quality Engineering to train inspectors to find this problem.
- REPORT BACK TO RPRB? No

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SPACE OPERATIONS

INFORMATION ON THIS PAGE WAS PREPARED TO SUPPORT AN ORAL PRESENTATION  
AND CANNOT BE CONSIDERED COMPLETE WITHOUT THE ORAL DISCUSSION